New Scientist

WEEKLY 15 June 2024

TINY GREAT APE
Meet our new ancient cousin

BEYOND ABSOLUTE ZERO
Atoms pushed to "impossible" temperature

OZEMPIC ON THE BRAIN
How the drug could help treat depression and addiction

WHERE SPACE-TIME ENDS

We are finally confronting the quantum weirdness at the heart of black holes

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Christopher Ward

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Among a raft of brilliant speakers at this year's festival, hear award-winning science writer Tom Chivers talk about Bayes's theorem, the formula that allows us to predict everything. Join us in person at New Scientist Live on 13 October at London's ExCeL Centre.

newscientist.com/nslmag

Tour

Niels Bohr's Copenhagen

Join journalist Manjit Kumar on a journey to the birthplace of quantum physics. Explore the sites where Niels Bohr formed his ideas about atomic structure and quantum theory, and find out how he became part of the Manhattan Project, which made the atomic bomb. Then enjoy a day trip to the historical city of Roskilde – now a centre for sustainable energy research. This six-day tour starts on 3 July and costs £2698.

newscientist.com/tours

Podcast

CultureLab

In the latest episode, features editor Abigail Beall interviews Lisa Kaltenegger, an astrophysicist and founding director of the Carl Sagan Institute in New York. She works out of Sagan's old office and shares the enthusiasm he brought to the search for extraterrestrial life. Kaltenegger speaks about her new book *Alien Earths*, which takes readers on a cosmic adventure to faraway exoplanets with oceans of lava and multiple suns.

newscientist.com/nspod

ESA/ATG MEDIALAB

Over the weather This newly launched satellite will study clouds

JOSE IRIARTE/LAST JOURNEY

The big picture Rock art is far more widespread than we thought

Video

Understanding clouds

The European Space Agency's EarthCARE satellite, which was launched in late May, is designed to give us a far better grasp of how clouds work and their influence on our climate – a key uncertainty that persists in climate change modelling. You can watch the launch and interviews with some of the key mission scientists on our YouTube channel.

youtube.com/newscientist

Newsletter

Our Human Story

News recently broke of the discovery of the largest known ancient rock art. The engravings, which depict snakes, were found in South America. In his latest newsletter, Michael Marshall explains how we used to think that such art was confined to Europe – discoveries like this show how wrong we were.

newscientist.com/our-human-story

Podcast

"There are weirder worlds than even science fiction has invented"

Essential Guide

What drives us to explore space? Are we returning to the moon for the wrong reasons? How are space probes rewriting our origin story? Discover the history and future of exploration beyond Earth in this *New Scientist Essential Guide*, now available to read in the app or buy in print from our online shop.

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Whatever works

We finally have a real solution to the obesity crisis, so let's be more open-minded

LATELY, it seems you can't open a newspaper without hearing about the latest celebrity opinion of Ozempic or the latest condition it is showing promise in treating. But as the popularity of the diabetes treatment turned weight-loss drug turned all-round panacea continues to climb, it is disappointing to see how critical much of the media discourse is.

This medicine – whose generic name is semaglutide and which is also sold under the brand name Wegovy – works by mimicking a gut hormone called GLP-1. After many false starts, it is the first weight-loss drug that is both safe and effective. Yet many column inches have been devoted to why we shouldn't see this type of medicine as a quick fix for our expanding waistlines, but should instead be encouraging people to alter their diets. Critics also warn that unsuspected negative effects may emerge. Both these opinions are somewhat short-sighted.

First, the more people who take these drugs, the more confident we can be that any new side effects would be rare. We have also discovered unanticipated positive effects. Not only do the GLP-1 mimics help in obesity-related conditions, but they have recently shown potential in unexpected areas, such as addiction, depression and Alzheimer's disease (see page 36).

"Ozempic won't be a quick fix for the obesity epidemic. But it might be a slow one"

Second, health services globally have been battling obesity for decades. Countless strategies – from healthy eating campaigns to school cooking lessons and calorie counts on menus – have been tried.

None has worked. It appears almost inevitable that as a country's prosperity rises, so too does its weight. Yet that might not be the case for much longer if Ozempic and the other, more potent GLP-1 mimics that are set to follow it deliver on their promise.

We aren't quite there yet. Ozempic has been priced out of reach for many people. However, the costs of new medicines tend to fall over time as competitors weigh in.

Ozempic won't be a quick fix for the obesity epidemic. But it might be a slow one – with added benefits. And to that we should be open. ▮

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Environment

Mass fish death in Mexican lake

Workers rush to spread quicklime over thousands of dead fish in the dry bed of the Bustillos Lagoon near the town of Anáhuac in Chihuahua state, Mexico. Temperatures have climbed above 40°C (104 °F) as drought has ravaged the region, lowering water levels. The fish are being covered to mask the smell and avoid decomposition that could endanger public health by spreading disease.

REUTERS/JOSE LUIS GONZALEZ

Physics

Atoms with 'impossible' temperature

Physicists have coaxed a cloud of atoms to a temperature beyond absolute zero and placed them in a structure that could be an unknown form of matter, discovers **Karmela Padavic-Callaghan**

A CLOUD of atoms with a temperature beyond absolute zero – which, bizarrely, is also hotter than any positive temperature – could be a strange new quantum state of matter.

Luca Donini at the University of Cambridge and his colleagues have put thousands of potassium atoms into this seemingly paradoxical situation by precisely manipulating their energy levels and quantum states. "Quantum mechanics allows you to do this,

"Quantum mechanics allows you to do this, while classical thermodynamics would never allow it"

while classical thermodynamics would never allow it," he says.

Normally, if you have a collection of atoms that are moving around quickly, with lots of kinetic energy, then the temperature is high. In contrast, slow-moving atoms with little kinetic energy have a low temperature. When all atoms are perfectly still, the Kelvin scale – used by scientists to measure temperature – hits absolute zero, the lowest value possible.

But physicists also have a more precise definition of temperature that reflects how energy is distributed among the atoms, a property related to a system's entropy, or how disordered it is.

For a collection of atoms with a positive absolute temperature, only a few of them have lots of energy, while most have lower energy levels. At absolute zero, all atoms have the same, minimal energy. But at negative absolute temperatures, the distribution flips, so higher-energy atoms become the majority, and those with lower energy become outliers.

This leads to one of the biggest oddities about negative absolute temperatures – that they are technically hotter than all positive temperatures. This is because a negative absolute temperature object will always have more energy, so putting it together with a positive temperature object would make heat flow into the latter, as from a warm room into a cold glass of water.

Donini and his team achieved this unusual temperature by putting potassium atoms into a vacuum chamber and cooling them very close to absolute zero using lasers and magnetic fields. This allowed them to control the quantum states and energies of the atoms, ultimately coaxing them into a negative absolute temperature.

The researchers presented the work at the annual meeting of the American Physical Society Division of Atomic, Molecular and Optical Physics in Fort Worth, Texas, on 5 June.

This kind of experiment was first performed in 2013, but now the researchers have carried out a more advanced version that allows them to arrange the negative temperature atoms into a pattern of hexagons and triangles called the Kagome lattice.

In this arrangement, the atoms can be pushed into a quantum state where all of their energy comes from interactions with other atoms, but they have no kinetic energy.

Physicists are unsure what kind of matter those properties will create, says team member Ulrich Schneider, also at the University of Cambridge, and they now face the challenge of pinning down the properties of this new quantum substance.

TANYALOVUS/SHUTTERSTOCK

Could a mysterious new quantum form of matter lurk beyond absolute zero?

Exotic behaviour

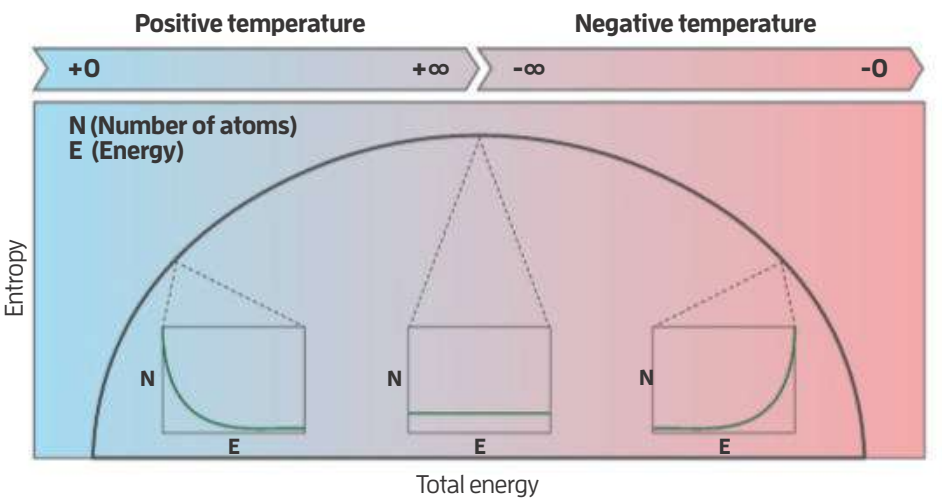
"We're going into unknown territory, and we are getting measurements, but interpreting them and knowing what they mean is not trivial," says Schneider.

Achim Rosch at the University of Cologne, Germany, says that exotic and rich quantum behaviours tend to emerge from particles arranged in Kagome lattices because of the very specific energies they can have in this arrangement and because of its intricate geometry.

For instance, some theorists predict that the atoms may form a fluid that flows with zero viscosity, an idea that seems contradictory when none of the atoms has any kinetic energy, and so should be unable to move. "There is a slew of possibilities of what could happen in this context," says Rosch.

Defining temperature

The absolute temperature of a cloud of atoms is related to both its total energy and how that energy is distributed among those atoms, which is in turn linked to its entropy, or disorder. For positive temperatures, most atoms in the cloud have low energy, while at negative absolute temperatures, the majority have high energy



Starliner and Starship propel space industry into a new era

SpaceX successfully launched its Starship rocket the day after Boeing's Starliner craft made its first crewed flight, a sign that the space industry is hotting up, says **Leah Crane**

SPACE flight is having a renaissance. Two rocket launches on 5 and 6 June demonstrated the capabilities of relatively new spacecraft, each representing a crucial step forward for human space exploration.

Boeing's Starliner capsule made its first crewed flight, taking two NASA astronauts to the International Space Station (ISS). The next day, SpaceX's huge Starship rocket made its fourth test flight, the first orbital flight it has fully executed without anything falling apart or exploding.

"Nothing blew up, so it was a really good day for space flight progress," says Laura Forczyk, an independent space industry consultant. She says the successes showcase the fact that we are operating in two different domains: sending humans to orbit, and moving quickly towards sending humans to the moon and beyond.

With this launch, Starliner joins SpaceX's Dragon class of spacecraft as a second option to carry US astronauts to the ISS. This marks the first time any country has had more than one active orbital spacecraft that could safely carry crew, a key achievement for NASA.

It is a striking change in a relatively short period of time. After the space shuttle programme ended in 2011, NASA had no other option but to rely on Russian spacecraft to fly US astronauts to the ISS, which continued until 2020.

"The US has had a strained relationship with Russia, so what we had was an adversarial relationship with a space flight partner on the ground, but still had to rely on them to get our astronauts to space," says Forczyk. "We want to have that capability independently, and we don't want to lose it if something went wrong with one of those spacecraft."

When Starliner docked with the ISS, it was the first time three different crewed vehicles were attached to the station at once. The other ships joining Starliner are the SpaceX Dragon Endeavour spacecraft and the Soyuz MS-25 crew ship. The busy ISS docks are a sign that the space flight industry is booming.

"It's the maturation of space flight," says Forczyk. "It starts with cargo to the space station, and then humans to the space station, and then commercial space stations and beyond."

Starship's success is a step towards that "beyond". It is the largest, most powerful rocket ever built, intended to eventually loft astronauts to the moon and Mars. While Starship still isn't reliable enough to carry a crew, the rate of testing and iteration of the craft is incredibly fast.

Delays are still ubiquitous in spacecraft testing because of the complexity of the hardware, but decades of effort are nevertheless coming to fruition. Aside from Starliner and Starship, a series of new spacecraft have flown in the past few years, including many missions to the moon and new orbital rockets around the globe.

This seemingly sudden progress is down to the increased involvement of private industry in space flight, which used to be an endeavour only available to huge national agencies, says Forczyk. "There's pressure [on the commercial space flight side] to develop quickly and become operational and fulfil their contracts and get their return on investment, so there's speed that wasn't there before," she says. This means it is getting easier and easier to send anything – science experiments, space stations, people – into orbit and further afield.

3

types of spacecraft have now docked with the ISS at once

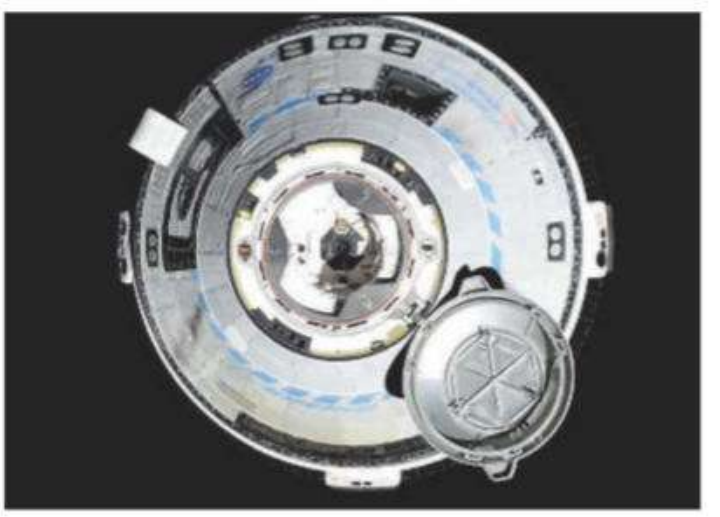
There is also a feedback effect in which each successful flight makes the next flight more likely to be successful and heats up the competition between the dozens of agencies and firms trying to make their mark on the cosmos. Humanity is expanding its reach beyond Earth, and our forays into the universe are beginning to multiply. These two launches are emblematic of that astonishing growth. ▮

Clockwise from below: SpaceX's Starship launch on 6 June; a crowd watching Starship's take-off; Boeing's Starliner approaching the International Space Station; a bell is rung to welcome the Starliner pilots on board

SPACEX

MICHAEL GONZALEZ/EPA-EFE/SHUTTERSTOCK

NASA



BOEING SPACE

Analysis Medication withdrawal

Does coming off antidepressants really cause withdrawal?

A study suggests that 1 in 3 people who stop taking the drugs get mental and physical symptoms, but what does that actually mean when these can also occur after discontinuing a placebo, asks **Clare Wilson**

ANTIDEPRESSANTS are one of the most commonly taken medications in high-income countries – and are among the most controversial. Just 10 years ago, some doctors may have doubted that antidepressant withdrawal symptoms happen very much at all. Now, a study has found that these reactions occur in as many as 1 in 3 people who stop taking the medicines, although they may not always be what they seem.

Most antidepressants used today belong to a group of drugs known as selective serotonin reuptake inhibitors, or SSRIs, which are seen as an advance on earlier kinds of such medication.

Since the arrival of these drugs for treating depression in the 1990s, doctors have increasingly offered them to people with a range of other mental health conditions, including anxiety and phobias. In England, for instance, about 1 in 7 people are taking these medicines.

This prevalence has led to concerns that they are being overused. SSRIs can have side effects such as agitation and blunted emotions. Another problem is that people can find it hard to stop taking them because of withdrawal symptoms, also sometimes called discontinuation symptoms.

The effects can be physical, such as headaches and nausea, or mental, like anxiety and depression, which can be confused with the return of the medical condition for which the antidepressant was originally prescribed. This matters because withdrawal symptoms may only last a few weeks, but if the mental symptoms represent a genuine return of depression or anxiety, then the person may need to start taking the medicine again.

DR P. MARAZZI/SCIENCE PHOTO LIBRARY

Antidepressants are widely dispensed in high-income countries

Withdrawal symptoms are thought to happen because SSRIs raise levels of a signalling molecule called serotonin within the connections between brain cells known as synapses. Indeed, it was originally thought that this is how they work, although such an explanation is now seen as too simplistic.

Regardless of the drugs' true mechanism of action, studies in animals have demonstrated that the body seems to adapt to SSRIs by reducing levels of other molecules in the serotonin signalling pathway, such as the receptors that serotonin normally binds to. "If you take away the antidepressant, only the 'counter-measures' are left," says Christopher Baethge at the University of Cologne in Germany.

In the latest analysis, Baethge's team reviewed 79 studies that had estimated how common withdrawal symptoms from antidepressants are.

It discovered that 31 per cent of people experienced these effects when stopping using the medicines, although so did 17 per cent of people in placebo groups (*The Lancet Psychiatry*, doi.org/m2qw). This suggests that about 14 per cent of people experience withdrawal symptoms that are genuinely due to the drugs' pharmacological actions, says Baethge.

This figure is lower than a previous estimate, which indicated that more than half of all people coming off the drugs experience withdrawal effects. But that study included those responding to internet surveys, who may have been more likely to take part if they had been badly affected.

On the other hand, the 14 per cent figure may be an underestimate, because the review included studies that hadn't been specifically designed to identify withdrawal symptoms and so some such problems may have been overlooked, says Anthony Kendrick at the University of Southampton in the UK.

Even if some people are having withdrawal symptoms purely because of psychological expectations, that can still be hard to cope with, says Kendrick.

Regardless of how accurate its results are, the latest analysis is likely to bring the problem of antidepressant withdrawal to wider attention. "It should be standard for every psychiatrist to inform patients, even before starting the antidepressants, about the risk of discontinuation symptoms," says team member Jonathan Henssler, also at the University of Cologne.

But the fact that such symptoms also arise in the placebo groups of the trials suggests that they can be triggered just by people expecting them to happen, he says. While doctors need to warn about the possibility of the effects, they should be careful to avoid giving people "very strong negative expectations", says Henssler. ▮

1 in 7

Proportion of people in England taking antidepressants

31%

Proportion of people across 79 studies from various nations who had withdrawal symptoms after stopping the drugs

Astrophysics

A cosmic cloud collision exposed Earth to interstellar space 3 million years ago

James Woodford

THE solar system encountered turbulence on a galactic scale between 2 million and 3 million years ago, colliding with a dense interstellar cloud that may have altered both the climate and evolution on Earth.

Merav Opher at Boston University and her colleagues have used the European Space Agency's Gaia satellite to uncover evidence that a dense hydrogen cloud, the Local Ribbon of Cold Clouds in the constellation Lynx, probably crossed paths with our sun as both travelled through the interstellar medium, the vast space between star systems.

Opher and her colleagues mapped the location of the dense cold cloud and the past trajectory of the sun. They propose that as the solar system collided with the cloud, it battered and shrank the heliosphere, the protective bubble formed by solar winds, which normally pushes to the edges of the solar system. Within the heliosphere, planets are largely shielded from galactic radiation.

The researchers think the heliosphere shrunk so far that Earth was left exposed outside the protective cocoon, possibly for as long as 10,000 years (*Nature Astronomy*, doi.org/m284).

Opher says the heliosphere's probable encounter with the cold cloud aligns with the deposition of the elements plutonium-244 and radioactive iron-60 in Antarctic ice, deep ocean cores and lunar samples. These elements, which originated in distant supernovae, are captured within interstellar clouds and were probably deposited on Earth while it was outside the heliosphere.

"The Earth's exposure to cold interstellar medium clouds and the related massive increase of hydrogen in the atmosphere and increased radiation almost certainly had a substantial impact on our planet and its climate," says Opher.

Sarah Spitzer at the University of Michigan says the paper provides "compelling" evidence that the heliosphere was exposed to a much denser interstellar cloud 2 million to 3 million years ago.

"This could have changed the evolutionary trajectories of organisms, including humans"

"Understanding this helps us learn about the effects of the interstellar medium on life on Earth in the past," she says. "But it also helps us better understand... what might happen if the Earth is exposed to the interstellar medium again in the future, and when that might happen."

Evan Economo at the Okinawa Institute of Science and Technology in Japan says it is intriguing to think about how encounters in "our local cosmic neighbourhood" may have affected the environment experienced by life on Earth.

"The heliosphere is part of the extended environment that organisms experience on the surface of the Earth, affecting climate and incoming radiation from space," says Economo.

"If we were outside the heliosphere for certain periods, this could have changed the evolutionary trajectories of a broad range of organisms, including humans. Such links are highly speculative at this point, but give us a new research direction," he says.

Zoology

Lemurs grow bigger testicles if other males are around

DOMINANT male lemurs enlarge their testicles when living with other males, putting them in a better position to successfully mate.

In many species, dominant males have larger testes than subordinates, often because they have more testosterone. Males in species that have lots of males living together often have bigger testicles than in species where only one male lives in a group. Because larger testicles can make more sperm, this improves a male's chances of fathering offspring if females mate with several males.

Gabrielle Bueno and Rebecca Lewis at the University of Texas at Austin tested if this pattern holds in a single population by measuring the testes of 23 adult male Verreaux's sifakas (*Propithecus verreauxi*) in Kirindy Mitea National Park in Madagascar over 13 years.

GABRIELLE BUENO

A male Verreaux's sifaka, a type of lemur that is found in Madagascar

This population of lemurs is made up of several groups, with some having only one male and others having multiple males. Although females hold the most social power, males have their own hierarchy. Dominant males have a brown stain on their chest due to constant scent marking, while subordinates have clean white torsos.

Bueno and Lewis found that stained males in multi-male groups have testicles that are, on average, 103 per cent larger than those of clean males within their group, and 31 per cent larger than those of stained males in single-male units (*International Journal of Primatology*, doi.org/m27k).

The stained lemurs in multi-male groups may be producing more testosterone than the other lemurs, or suppressing the amount the clean males can produce, says Bueno. She says this shows that dominant males invest more energy in sperm competition when there are other males around. This "highlights how insanely flexible they are and how in tune they are with their social environment", says Bueno.

Sophie Berdugo

Mathematics

Confusion over what 'equals' means

For mathematicians, the equals sign can have more than one meaning, which is causing issues for computers checking proofs. A fix may mean tearing up the foundations of maths, finds **Alex Wilkins**

WHEN you see "2 + 2 = 4", what does "=" mean? It turns out that is a complicated question, because mathematicians can't agree on the definition of what makes two things equal. While this argument has been quietly simmering for decades, a recent push to make mathematical proofs checkable by computer programs, called formalisation, has given the argument new significance.

"Mathematicians use equality to mean two different things, and I was fine with that," says Kevin Buzzard at Imperial College London. "Then I started doing maths on a computer." Working with computer proof assistants made him realise that mathematicians must now confront what was, until recently, a useful ambiguity, he says – and it could force them to completely redefine the foundations of their subject.

Easy as ABC

The first definition of equality will be a familiar one. Most mathematicians take it to mean that each side of an equation represents the same mathematical object, which can be proven through a series of logical transformations from one side to the other. While "=", the equals sign, only emerged in the 16th century, this concept of equality dates back to antiquity.

It was the late 19th century when things began to change, with the development of set theory, which provides the logical foundations for most modern mathematics. Set theory deals with collections, or sets, of mathematical objects, and it introduced another definition of equality: if two sets contain the same elements, then they are equal, similar to the original mathematical definition. For example, the sets {1, 2, 3} and {3, 2, 1} are equal, because the order of the elements in a set doesn't matter.

"We're finding that we were a little bit sloppy all along, and that maybe we should fix a few things"

However, as set theory developed, mathematicians started saying that two sets are equal if there is an obvious way to map between them, even if they don't contain exactly the same elements, says Buzzard.

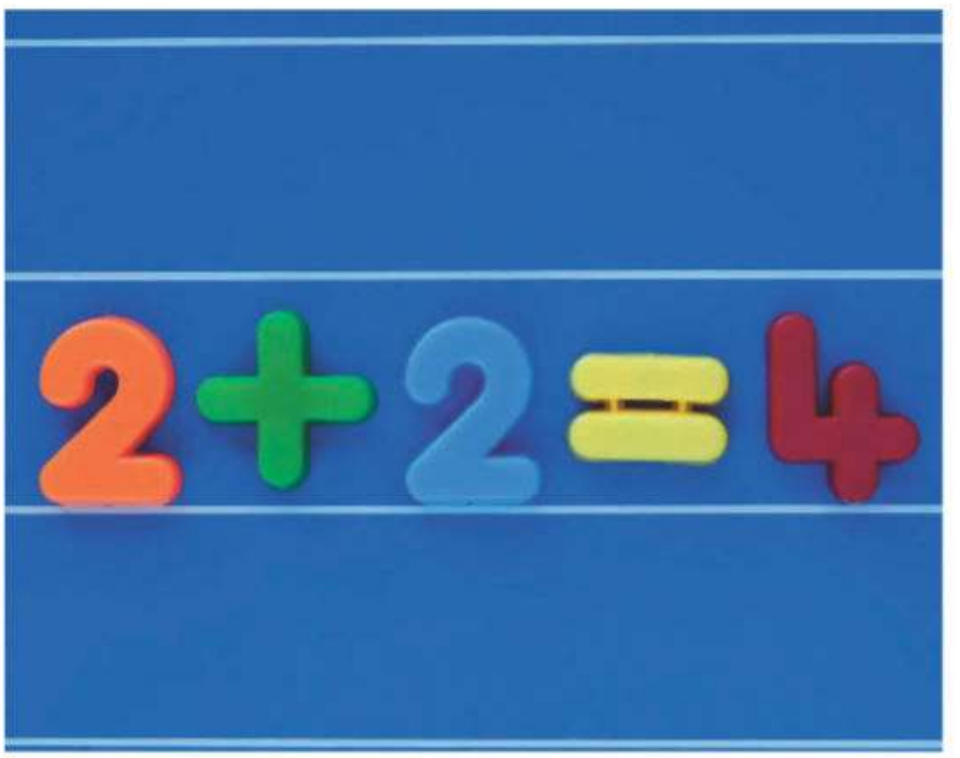
To understand why, take the sets {1, 2, 3} and {a, b, c}. Clearly, the elements of each set are different, so the sets aren't equal. But there are also ways of mapping between the two sets by identifying each letter with a number. Mathematicians call this an isomorphism. In this case, there are multiple isomorphisms because you have a choice of which number to assign to each letter, but in many cases, there is only one clear choice, called the canonical isomorphism.

Because a canonical isomorphism of two sets is the only possible way to link them, many mathematicians now take this to mean they are equal, even though it isn't technically the same concept of equality that most of us are used to. "These sets match up with each other in a completely natural way and mathematicians realised it would be really convenient if we just call those equal as well," says Buzzard.

Having two definitions for equality is of no real concern to mathematicians when they write papers or give lectures, as the meaning is always clear from the context, but they present problems for computer programs, which require strict, precise instructions, says Chris Birkbeck at the University of East Anglia, UK. "We're finding that we were a little bit sloppy all along, and that maybe we should fix a few things."

To address this, Buzzard has been investigating the way some mathematicians widely use canonical isomorphism as equality and the problems this can cause with formal computer proof systems (arXiv, doi.org/m2sf).

In particular, the work of Alexander Grothendieck, one of the leading mathematicians of the 20th century, is currently extremely difficult to formalise. "None of the systems that exist so far capture the way that mathematicians such as Grothendieck use the equal symbol," says Buzzard.



ASPIX/ALAMY

This might seem like a simple sum, but it is more complex than it looks

Truth without proof

The problem has its roots in the way mathematicians put together proofs. To begin proving anything, you must first make assumptions called axioms that are taken to be true without proof, providing a logical framework to build upon. Since the early 20th century, mathematicians have settled on a collection of axioms within set theory that provide a firm foundation. This means they don't generally have to use axioms directly in their day-to-day business because common tools can be assumed to work correctly – in the same way you probably don't worry about the inner workings of your kitchen before cooking a recipe.

"As a mathematician, you somehow know well enough what you're doing that you don't worry too much about it," says Birkbeck. That falls down, however, when computers get involved, carrying out maths in a way that is similar to building a kitchen from scratch for every meal. "Once you have a computer checking everything you say, you can't really be vague at all, you really have to be very precise," says Birkbeck.

To solve the problem, some

mathematicians argue we should just redefine the foundations of mathematics to make canonical isomorphisms and equality one and the same. Then we can make computer programs work around that. "Isomorphism is equality," says Thorsten Altenkirch at the University of Nottingham, UK. "I mean, what else? If you cannot distinguish two isomorphic objects, what else would it be? What else would you call this relationship?"

Simpler solution

Efforts are already under way to do this in a mathematical field called homotopy type theory, in which traditional equality and canonical isomorphism are defined identically. Rather than trying to contort existing proof assistants to fit canonical isomorphism, says Altenkirch, mathematicians should adopt type theory and use alternative proof assistants that work with it directly.

Buzzard isn't a fan of this suggestion, having already spent considerable effort using current tools to formalise mathematical proofs that are needed to check more advanced work, such as a proof of Fermat's last theorem.

"It's very difficult to change mathematicians. You have to make the computer systems better"

Rather than adopting type theory, he says, the axioms of mathematics should be left as they are and existing systems should be tweaked instead. "Probably the way to fix it is just to leave mathematicians as they are," says Buzzard. "It's very difficult to change mathematicians. You have to make the computer systems better." ▮

Technology

Diet-monitoring AI tracks every spoonful you eat

Matthew Sparkes

ADDICTIVE STOCK CREATIVES/ALAMY

AN ARTIFICIAL intelligence that watches you while you eat aims to automatically gauge the calories and nutrients in each spoonful, letting you leave calorie counting to a machine while you enjoy your meal.

Using AI to measure these facets of what you consume isn't a new idea, with previous models able to take an image of food on a plate and provide an estimate. But in an image of a meal, some items – such as ingredients submerged in a bowl of stew – are easy to miss, says Yuhao Chen at the University of Waterloo in Canada.

To address this, Chen and his colleagues have developed a new model that analyses a spoonful at a time. This approach is more accurate and could be a useful way of monitoring calories and nutrition, particularly for people who are ill or elderly, he says.

Their version analyses video of a person eating and detects each spoonful of food they consume. It then estimates the volume of food on the spoon. The discrepancy between this and actual measurements is as little as 4.4 per cent (arXiv, doi.org/m2sd).

The system isn't yet able to identify foods and estimate their nutritional content, but Chen says the team is working on this. Ultimately, the hope is that the tool will be able to recognise a wide range of different foods, even those it hasn't seen before, and analyse food held with a fork, a hand or chopsticks.

An AI model would typically be trained on images of food with accurate labels, but Chen hopes to integrate large language models into such a system to help it identify ingredients in unseen recipes, or even novel recipes.

"We're shifting towards using those large language models like ChatGPT to leverage the common knowledge to understand what is in the food or maybe ask a basic question [like] 'is this chicken?'," says Chen. "A lot of time, especially for people eating at home, the dish may not be a named dish. It may be just whatever is available in the fridge that they've mixed together."

An AI can analyse what you consume, so long as you use a spoon

Emilie Combet Aspray at the University of Glasgow, UK, says remote measuring of calories can't provide 100 per cent accuracy, so it may not be useful for strict scientific studies.

"There's a lot of variability in vitamins in carrots," says Combet Aspray. "There's a lot of variability for everything in everything, and your specific carrot eaten today may be anywhere on that scale. A real challenge is the processing methods that we use to put food on our plates or, for example, estimating the amount of oil that has been used to fry a piece of meat. Those kind of camera-based tools aren't necessarily able to evaluate that."

But the AI tool could be valuable for nutritionists and dieticians, or for any application where an approximation is good enough, such as for individuals tracking their calorie and nutrient intake, says Combet Aspray. ▮

Climate change

Earth warms as heat trapping doubles

Our planet's atmosphere is holding on to twice as much heat now as it did 20 years ago, raising concerns about how much energy the oceans are absorbing, says **Madeleine Cuff**

THE scales are inexorably tipping ever further in one direction as our planet's energy imbalance grows. Earth's atmosphere is trapping more than twice as much excess heat as it did in 1993, making scientists increasingly concerned about the impact on the world's oceans.

The planet's energy imbalance is a measure of how much surplus heat there is in the climate system. It is the difference between how much energy enters Earth's atmosphere from the sun and how much is radiated back into space.

Earth has been absorbing more energy than it emits for decades, as increased concentrations of greenhouse gases in the atmosphere trap more heat from the sun.

Less energy leaving

This energy imbalance in the atmosphere has increased sharply in recent years, according to estimates based on data from ocean buoys, published in the latest Indicators of Global Climate Change study. Between 1974 and 1993, Earth's average energy imbalance was 0.42 watts per square metre, but between 2004 and 2023 it more than doubled to 0.87 W/m^2.

"The Earth is out of energy balance, which is due to the greenhouse gas effect. There is less energy leaving the system," says Karina von Schuckmann at Mercator Ocean International, a non-profit group based in France.

The Indicators of Global Climate Change, co-authored by von Schuckmann and more than 50 other climate scientists, is published annually to provide an update on the state of the world's climate (*Earth System Science Data*, doi.org/m27m).

The study follows the same methodologies as the Intergovernmental Panel on Climate Change and aims to act as an interim update to the IPCC's comprehensive but infrequent assessments.

The most recent IPCC assessment, which was published in 2021, estimated Earth's energy imbalance at 0.79 W/m^2 during the period 2006 to 2018.

The energy imbalance has been increasing since the 1970s due to higher greenhouse gas emissions and lower air pollution, which helps bounce heat back into space. Previous studies using satellite sensors have concluded that Earth's energy imbalance has doubled since 2005.

This is worrying news for the world's oceans, which are absorbing around 90 per cent of this excess heat. The oceans have been warming at record-breaking rates every year since 2019, research shows. The oceans are "our sentinel for planetary warming", says von Schuckmann.

"Earth energy imbalance isn't just some sort of esoteric quantity. It's got real-world implications"

The additional heat is warming ocean waters, making them less effective at capturing carbon dioxide from the air, driving sea level rise and severely affecting marine life. Some of the changes could be permanent.

Recent studies also suggest that the excess warmth is penetrating into the deep ocean, to depths of up to 2000 metres. This heat will take thousands of years to resurface, and in the meantime could affect ocean currents, oxygen levels and marine chemistry.

"Earth energy imbalance isn't just some sort of esoteric quantity that scientists like to look at. It's got real-world implications," says Norman Loeb at NASA Langley Research Center in Virginia.

Studies also suggest that the rate of acceleration in global ocean heating has increased over the past 20 years, indicating the rate of change for Earth's energy imbalance is also rising. This may be in part due to a diminishing albedo effect – as warmer temperatures melt snow and ice, there is less white surface on Earth to reflect the sun's heat.

Records tumbling

The rate of increase has jumped sharply even since the 2022 Indicators of Global Climate Change report, which estimated the energy imbalance at 0.89 W/m^2 for the 2010-2022 period. This year's paper puts it at a record 0.96 W/m^2 over the 2011-2023 period.

Last year saw record-breaking air and ocean temperatures, driven primarily by climate change and a global swing to El Niño, a natural climate variation that brings warmer temperatures.

The jump in energy imbalance in 2023 is probably due to this sudden switch to El Niño, says Loeb. "Traditionally, when you have La Niña, the climate system takes up energy. And then when you have El Niño, it releases energy," he says. "When you go from La Niña to El Niño, it packs a big punch."

Alongside warnings about the increase in energy imbalance, the latest Indicators of Global Climate Change study also cautions that global average temperatures are rising at 0.26°C per decade, double the pre-1983 warming rate. With emissions at the current level, the world has just five years left before the 1.5°C temperature goal is broken. ▮

BETTMANN/GETTY IMAGES

More of the sun's heat is getting trapped by Earth's atmosphere

Space

Physicists want to drill 5 kilometres down into the moon

Alex Wilkins

DIGGING a deep hole in the moon could finally give us evidence that protons can fall apart, claim a group of researchers. This would help efforts to unify physics theories.

The standard model of particle physics – our best working picture of how fundamental forces and particles interact – says protons are stable, living forever. But this model fails to unite quantum mechanics with the theory of relativity, which describes gravity. In contrast, some proposed unified theories stipulate that protons can decay into other particles, albeit rarely.

That means if we were to find evidence of proton decay, these more complete models could be correct, but experiments on Earth have failed to see this happening.

Now, Patrick Stengel at the National Institute of Nuclear Physics in Ferrara, Italy, and his colleagues are proposing digging deep into the moon to search for signs of ancient protons decaying into kaons, which are made up of two elementary particles called quarks.

They say the dense lunar rock could preserve evidence of such decay in chemical changes in its mineral structure. Being deep down, and hence well shielded, would also mean that such evidence wouldn't be confused with lookalike reactions caused by things such as high-energy neutrinos, which can affect experiments on Earth.

The researchers calculate that the shielding would be sufficient at least 5 kilometres under the lunar surface, so a powerful drill would need to be transported to the moon to obtain the sample (arXiv, doi.org/m2q2). The rock sample would then be analysed on the moon because transport to Earth could alter it.

Despite the difficulty, assessing just 100 grams of lunar rock could be enough to search for proton decays with as much sensitivity as the biggest projects on Earth. ▮

Technology

Dutch police want autonomous robot dogs to inspect drug labs

Matthew Sparkes

QUANG NGUYEN DUC/ALAMY

Spot robotic dogs from Boston Dynamics have many uses

THE Dutch police are planning to use an autonomous robotic dog in drug lab raids to avoid placing officers at risk from criminals, dangerous chemicals and explosions. If tests in mocked-up scenarios go well, the artificial intelligence-powered robot will be deployed in real raids, say police.

Simon Prins at Politie Nederland, the Dutch police force, has been testing robots in criminal investigations for more than two decades, but says they are only now growing capable enough to be practical for more complex jobs. One such job is raids on illegal drugs laboratories, which are carried out by the police force three or four times a week and require officers to risk their safety by dismantling equipment.

"When the lab is in operation and you stop it, it can explode," says Prins.

He says the force already has a Spot robotic dog from Boston Dynamics, fitted with a robotic arm, which has been used under manual control for investigating drug labs for some time, as well as in other operations such as surveillance.

But researchers from the Netherlands Organisation for Applied Scientific Research and the police are now conducting trials in mock-up drug labs with the robot under AI control – which they hope will free up human officers for other jobs and make operations faster and more efficient.

"I want those guys being busy with the operation and

"When the illegal drugs lab is in operation and you stop it, it can explode"

not being busy with a robot. So that's the game that we are playing now: how autonomous can we make it?" says Prins.

Police officers have been injured in the past while dismantling sites such as drug labs, so the hope is that robots could make initial inspections, check that no people are present, build a map of the location and identify dangerous chemicals. Once that is done, officers can plan a safe way to dismantle the lab.

In tests, the robot was able to explore and map a 15-metre by 20-metre mock drug lab. It found dangerous chemicals and placed them into a safe storage container (arXiv, doi.org/m2qx).

Prins says there are understandable safety and political concerns with using autonomous robots that will demand rigorous testing, but that the Spot dog will eventually be tested in real drug lab raids if all goes well.

Peter Lee at the University of Portsmouth, UK, says the benefits of AI-controlled robots in scenarios like drug lab raids are huge. While real dogs must be trained individually, robots can easily be replicated once their software has been created, and their suite of sensors means they can speed up investigations. But human safety is the most compelling aspect, he says.

"One of the drugs labs might blow up and take the robot with it," says Lee. "But I would rather use a robot that you can replace than a dog or a human."

Lee says concerns about autonomous robots in these scenarios are misplaced because the machines will operate within set parameters under the watch of humans, but he says risks must be monitored.

"You just need to make sure that humans don't get overly reliant on the machine because sometimes machines will get things wrong," he says. "The caveat is they have to be really thoroughly field-tested. And then when you start to use them, I would say that you probably have to use them in places where, if all goes wrong, you can do the least harm." ▮

Animal domestication

How humans reshaped the horse

A genetic analysis reveals how equine breeding techniques developed 4200 years ago

Christa Lesté-Lasserre

ANCIENT breeders dramatically shortened the natural generation times of horses starting about 4200 years ago, according to a genetic study of hundreds of ancient horses.

This led to a massive expansion of those bloodlines across Eurasia within a few centuries, says Ludovic Orlando at the Centre for Anthropobiology and Genomics of Toulouse, France. "They controlled the reproduction of the horse."

Horses were first domesticated 5500 years ago by the Botaï people in what is now Kazakhstan, but they didn't spread their horse culture elsewhere, says Orlando. The Botaï eventually died out and their horses returned to the wild.

More than a thousand years later, a different line of horses became domesticated in the Pontic-Caspian steppes of southern Russia. It was this line that ultimately spread across the planet, leading to every domestic horse in the world today, he says.

To chart the history of horse husbandry, Orlando and his colleagues analysed the genomes of 475 ancient horses from Eurasia dating up to 50,000 years ago. They compared those with the genomes of 71 modern domestic horses representing 40 breeds worldwide, as well as six endangered Przewalski's horses, which are a different sub-species.

"Breeders controlled the reproduction of the horse so generations were passing faster and faster"

The team confirmed that before the 3rd millennium BC, horses weren't being bred or domesticated – except among the Botaï. This means horses didn't contribute to human migrations and cultural expansions before that time, contrary to some theories, says Orlando.

The DNA analysis revealed significant inbreeding 4200 years ago in the Pontic-Caspian steppe horses, probably because people aimed to develop specific traits for riding and chariot horses, he says.

SHUTTERSTOCK/PIU_PIU

The domestication of horses began on the Eurasian steppes

Then, using a new technique combining genome sequencing and carbon dating, the scientists estimated the average number of years between two successive generations. That interval halved compared with the gap in the wild during the same period of massive inbreeding in the Pontic-Caspian steppes (*Nature*, doi.org/m2q8).

"Right at the time of the domestication bottleneck, around 2200 BC, this is when breeders managed to control the reproduction of the horse so much that generations were ticking faster and faster," says Orlando. The breeders were probably mating them at younger ages than they would in the wild, he says.

Christine Aurich at the University of Veterinary Medicine Vienna suspects the shortened generations were probably due to better survival rates rather than younger breeding ages. "It must be assumed that for horses living in the care of humans, losses of mares and their newborn foals were considerably reduced in comparison to horses living under wildlife conditions," she says. ▮

Medical technology

Tiny brain sensor dissolves after a few weeks

A SENSOR can be injected through the skull with a needle to help monitor brain health before it dissolves within weeks. It has been tested in animals and could one day enable minimally invasive implants to monitor traumatic brain injuries or conditions like epilepsy in people.

"As far as I know, this is the first wireless sensor that can be used to monitor conditions within the body without requiring any surgery," says Jules Magda at the University of Utah, who wasn't involved in the work.

Jianfeng Zang, who is at Huazhong University of Science and Technology in China, and his colleagues created their 2-millimetre-wide sensor using a cube of soft hydrogel. When an external source of ultrasound waves is applied to it, air channels spaced throughout the hydrogel direct the reflection of the ultrasound. The shape of the sensor deforms in response to changing conditions in the brain, which can be seen in the reflected ultrasound. "No wires or electronics are needed," says Zang.

HANCHUAN TANG; JIANFENG ZANG

This brain sensor made of hydrogel is small enough to be injected into the body using a needle

Zang and his team showed that these sensors can measure pressure, temperature, pH level and the flow rate of nearby blood vessels when injected into the brains of rats and pigs. They found comparable results to wired probes that are usually used to monitor brain health.

To inject this sensor into the brain, a large-diameter needle is required, which could still cause pain and discomfort, says Magda.

The experiments also found that the device breaks down into relatively harmless components, such as water and carbon dioxide, within five weeks (*Nature*, doi.org/m2q7). Safety and toxicity tests will be needed to show that such materials perform reliably and safely before any human clinical trials can start, says Zhang. ▮

Jeremy Hsu

Astronomy

A dead star is dying again as we watch

James Woodford

AN ALREADY dead star appears to be reaching the end of its second life, say astronomers who have spotted a pulsar that is gradually losing its spin.

Pulsars are a form of neutron star, which are remnants of a massive star that reached the end of its life in a supernova explosion. They get their name because they spin rapidly, usually many times a second, releasing beams of radiation that appear to "pulse" when viewed from Earth. It is thought pulsars gradually slow down, eventually crossing a "death-line" as their rotation reaches a low enough level, but this has never been observed.

Now, Manisha Caleb at the University of Sydney, Australia, and her colleagues say they have spotted an object called ASKAP J1935+214 that appears to be a pulsar spinning at a relatively measly 54 minutes per rotation, suggesting it is dying for a second time. "This object is in the neutron star graveyard," says Caleb.

The researchers, who discovered the star in October 2022 using the Australian Square Kilometre Array Pathfinder radio telescope, say it is about 16,000 light years away. They have seen the star exhibit three states: a strong pulse of radio waves lasting tens of seconds, a weak one lasting hundreds of milliseconds and a resting mode with no pulses (*Nature Astronomy*, doi.org/m2q4).

"No other object that we know of does this," says Caleb. "This suggests that something is physically changing in the object that we do not understand."

Another possibility is that the object is a magnetic white dwarf, which is a star that hasn't collapsed to the same density as a neutron star. But radio emissions have never been seen coming from a magnetic white dwarf, so Caleb says it is more likely to be a neutron star. ▮

Palaeontology

Tiny great ape may have lived in Europe, hints fossil finds

Christa Lesté-Lasserre

BÖHME ET AL., 2024, PLOS ONE, CC-BY 4.0

Two teeth, viewed from many angles, of the ape *Buronius manfredschmidi*

A SMALL, vegetarian great ape may have lived in western Europe 11.6 million years ago. Smaller and lighter than any other known great ape, the newly discovered 10-kilogram primate was a skilled climber that probably ate leaves, says Madelaine Böhme at the University of Tübingen in Germany.

"It's quite a small primate," she says. "But it differs from all known fossils and, of course, all living great apes we know so far."

11.6

The age of the ape's tooth fossils in millions of years

About 15 million years ago, in the middle of the Miocene Epoch, apes – or hominoids – became rarer in Africa and more abundant in Europe. While they sometimes shared habitats with other primates such as pliopithecoids – extinct cousins of apes and Old World monkeys – hominoid species didn't appear to coexist with each other in Europe.

In 2019, Böhme and her colleagues reported the discovery of 37 bones at Bavaria's Hammerschmiede archaeological site that appeared to come from an early bipedal ape from 11.6 million years ago, which they named *Danuvius guggenmosi*.

During the excavations, Böhme also found two tiny, ape-like teeth and a kneecap in the same layer of sediment as the *Danuvius* fossils. "We kept saying: 'What is this?'" she says of these smaller fossils. "And then we decided, OK, it's clear: this is something new."

The fossils are too old for DNA analysis, says Böhme. So the researchers took detailed measurements of the 7-millimetre-long molar and the 16-millimetre-wide kneecap, both from a juvenile, as well as a smaller premolar fragment, which they say came from a young adult. They also calculated the thickness of the enamel and ran microscopic CT scanning of the teeth.

The thin enamel, like that of gorillas, suggests a soft diet probably composed of leaves, says Böhme. The shape, thickness and ligament attachment sites of the kneecap resemble those of tree-living primates, hinting that the ape was a proficient climber.

The researchers named the new species *Buronius manfredschmidi*, after the medieval name of a city near the Hammerschmiede site, and a dentist named Manfred Schmid who has been collecting fossils from the site since the 1970s (*PLoS One*, doi.org/m27n).

Lack of competition for resources might explain why the *Buronius* and *Danuvius* apes could live together, says Böhme. *Danuvius* is thought to have eaten hard foods like nuts and possibly meat. The team can't rule out the possibility that the larger ape, which might have been up to three times heavier, may have sometimes fed on the smaller species, she adds.

However, the three fossils might not be sufficient to reach such grand conclusions, says Sergio Almécija at the American Museum of Natural History in New York City. "Could the smaller fossil elements belong to an infantile *Danuvius* individual?" he asks. "The teeth certainly look like they could be deciduous [baby teeth]." He also wonders whether the kneecap represents the same species as the teeth.

Clément Zanolli at the University of Bordeaux, in France, also has doubts. "It is not very clear to me if the teeth – and in particular the molar – belong to the hominoids or to another primate superfamily, the pliopithecoids."

Böhme and her colleagues say their comparisons ruled out the chances that the teeth are baby or pliopithecoid teeth.

In any case, the possibility that two species shared the same habitat and perhaps even interacted with each other is a "fantastic discovery", says Zanolli. "This shows once again that, at that time, Europe was a luxurious and hospitable place for primates to evolve." ▮

Health

Gene therapy lets deaf children hear

Five children have had gene therapy to treat inherited deafness in both ears, following the success of earlier treatments in just one ear. **Michael Le Page** reports

A GROUP of children in China who were born deaf can now hear with both ears after getting gene therapy to provide a normal copy of a mutated gene. The degree of hearing varies from child to child, but all can now hear voices at a conversational volume and locate the source of sounds.

Six months after treatment, the five children's hearing was around 50 to 60 per cent of normal levels, says team member Zheng-Yi Chen at the Mass Eye and Ear hospital in Boston. "When we whisper, they have a difficult time, but normal conversation is fine," he says. "We're very happy."

EYE & ENT HOSPITAL/FUDAN UNIVERSITY

Team member Yilai Shu with one of the young study participants at the Eye & ENT Hospital of Fudan University in China

Continuous improvement

In the first part of this trial, which began in 2022, the team gave a separate group of six children in China gene therapy in one ear only. Five of the six gained hearing in the treated ear and are still continuously improving, says Chen.

The team expects the second group of five children to have further gains too. "What we see now is not the peak of the improvement," says Chen. "We expect it to improve further."

The trial in China is the first of several getting under way around the world, with two children in the UK and one in the US also reported to have gained hearing in one ear after receiving gene therapy.

"The trials are all broadly similar," says Manohar Bance at the University of Cambridge, who treated the two children in the UK.

All the children in these trials were born deaf because they have mutations in both copies of the gene for a protein called otoferlin. This plays a key role in the synapses, or links, between the hair cells in the ear that detect sound and the nerves that carry the signals to the brain. The mutations affect the protein, preventing the signals from being transmitted.

Between 2 and 8 per cent of the children born deaf around the world are thought to have this condition, known as DFNB9.

The parents of children with DFNB9 have normal hearing if they each have just one mutated copy of the otoferlin gene. Such couples are usually unaware they have a 1 in 4 chance of having a child who is born deaf.

2-8%
Proportion of children born deaf who have a condition called DFNB9

5
Number of children with DFNB9 who have had both ears treated

50-60%
After six months, hearing was at this percentage of normal levels

Gene reassembly

The gene therapy involves delivering a working version of the otoferlin gene to the hair cells with the help of a virus called AAV. Because of the size of the otoferlin gene, it has to be split and put into two separate viruses.

A mixture of the viruses is injected into the inner ear and the complete gene is then reassembled inside cells that get both of its halves. The DFNB9 trials are the first time that dual AAV gene therapy, as it is known, has been used to treat people (*Nature Medicine*, doi.org/m2k3).

"We expect to see very broad use of the technology for treating other genetic diseases"

"This is a big technological advancement," says Chen. "We expect to see very broad use of the technology for treating other genetic diseases."

The trials start by treating just one ear at a time because this requires half the dose of AAV, he says, reducing the odds of any adverse events. No serious adverse events have been reported in any of the trials.

Chen's team now plans to treat the other ears of the children in the first group. This might be tricky because the immune response to the initial AAV injection could block gene delivery, but Chen thinks it will be possible.

Treating other forms of inherited deafness will be harder, says Chen, because these result in the degeneration of some structures within the ear. With DFNB9, all the structures remain intact. "We just need to fix one component," he says.

Some people don't see deafness as a condition that needs to be cured, points out Martin McLean at the UK's National Deaf Children's Society. The society's position is that families should be free to make informed decisions for themselves.

"Parents or young people should be made aware of any risks, and, above all, understand that being deaf is not a barrier in itself to a happy and fulfilled life," he says. ▮

Technology

Writers accept lower pay when using AI to help them with work

Chris Stokel-Walker

PEOPLE will take a 28 per cent pay cut when they can use a chatbot powered by a large language model (LLM) to assist with their writing job. This is seen as a trade-off for saved labour, but it suggests that artificial intelligence tools will reduce the value of creative writing as a profession, say researchers.

"We were curious about how generative AI can contribute to the creation process, and if it can make work easier for the worker," says Chen Liang at the University of Connecticut. "And if that's the case, how will that affect the workers' valuation of generative AI?"

Liang and her colleagues asked 379 people on the Prolific online research platform, which sets paid tasks, to produce a piece of writing about half the length of this article within 45 minutes. Some were told to write an essay-style piece, arguing in favour of a subject, while others were asked to continue a fictional story based on a prompt.

Participants were given the chance of completing tasks in one of three modes: independently, without any AI assistance; human-primary, where ChatGPT could assist them in polishing their own work; or AI-primary, where ChatGPT would write the first draft and the person would then edit it.

Some were given the choice between human-primary and independent writing, while others could opt for AI-primary or independent writing. Those who worked independently were always given $3 for finishing their task. AI-assisted tasks were offered to workers with a random amount between $1.50 and $4.50, at $0.25 intervals.

"We were able to tell, everything else being equal, how much money they were willing to give up in order to get this AI system," says team member Ming Yin at Purdue University in Indiana.

The participants were willing to forgo around $0.85, or 28 per cent of the total amount they would have been paid for a job, in order to have a first draft written by AI – far more than the $0.10 pay cut deemed acceptable to have AI check your work (*CHI '24: Proceedings of the CHI Conference on Human Factors in Computing Systems*, doi.org/m2m7).

28%

Pay cut that people will accept if using a chatbot to help them write

Liang says the pay cut reflects how much the workers valued the help AI provided them in completing the task, rather than their perception of how much less their finished work ought to cost due to diminished quality. The researchers also asked the participants to rate the quality of the work they produced with and without AI assistance and found little meaningful difference.

"The finding is worrisome because it supports a key business case for LLMs, which is that employers will be able to save money on human labour costs by incorporating this technology into the workplace," says Mike Katell at the Alan Turing Institute, London. "That could be great for employers, but of highly questionable value for paid writers."

He says the findings have concerning implications for writers. "The basic unsubtle message here is that LLMs can make creative writing less specialised and thereby less valuable overall, and that will drive down the demand power for any writer, regardless of whether they use an LLM." ▮

Zoology

How bats pick out their own calls when flying in a swarm

IF YOU struggle to hear a conversation in a noisy room, imagine what it is like for a bat amid a colony of thousands trying to navigate by emitting ultrasonic calls and listening out for the echoes. Now we know they do it by subtly altering their own calls.

"They come out in swarms, and it's chaos," says Laura Kloepper at the University of New Hampshire. To investigate how the animals can distinguish calls, she and her team trained a Harris's hawk to fly through a swarm of bats while wearing a backpack equipped with tiny microphones and cameras. Guided by people positioned along its path, the hawk flew 23 passes through 600,000 bats that had emerged from the Jornada caves, New Mexico, for their evening meal and travelled through a canyon.

LAURA KLOEPPER

Some of the hundreds of thousands of bats that roost in the Jornada caves, New Mexico

The researchers extracted characteristics of each bat's "voice" from recordings. They teased out tiny differences from one individual's call to the next and found that these drive enormous differences in the signal that returns to a bat. This makes it easier for each bat to compare a returning echo to the one it sent out and ignore the input that doesn't match.

"Really subtle changes have a big impact on whether a bat accepts or rejects the return signal," says Kloepper. This is called a jamming avoidance response, where a bat shifts its call to minimise interference from those of neighbours. The team presented its work at a meeting of the Acoustical Society of America in Ottawa, Canada, last month.

"It's very novel to put the hawk in the mix," says Cynthia Moss at Johns Hopkins University in Maryland, but using a predator may affect the bats' behaviour. Using drones might stop that, says Kloepper, but these are noisy, while the silent raptor doesn't disturb sound monitoring. ▮

Rachel Berkowitz

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Bethan Ackerley on *The Leftovers*, a jewel of a TV show p30

Comment

Through a baby's ears

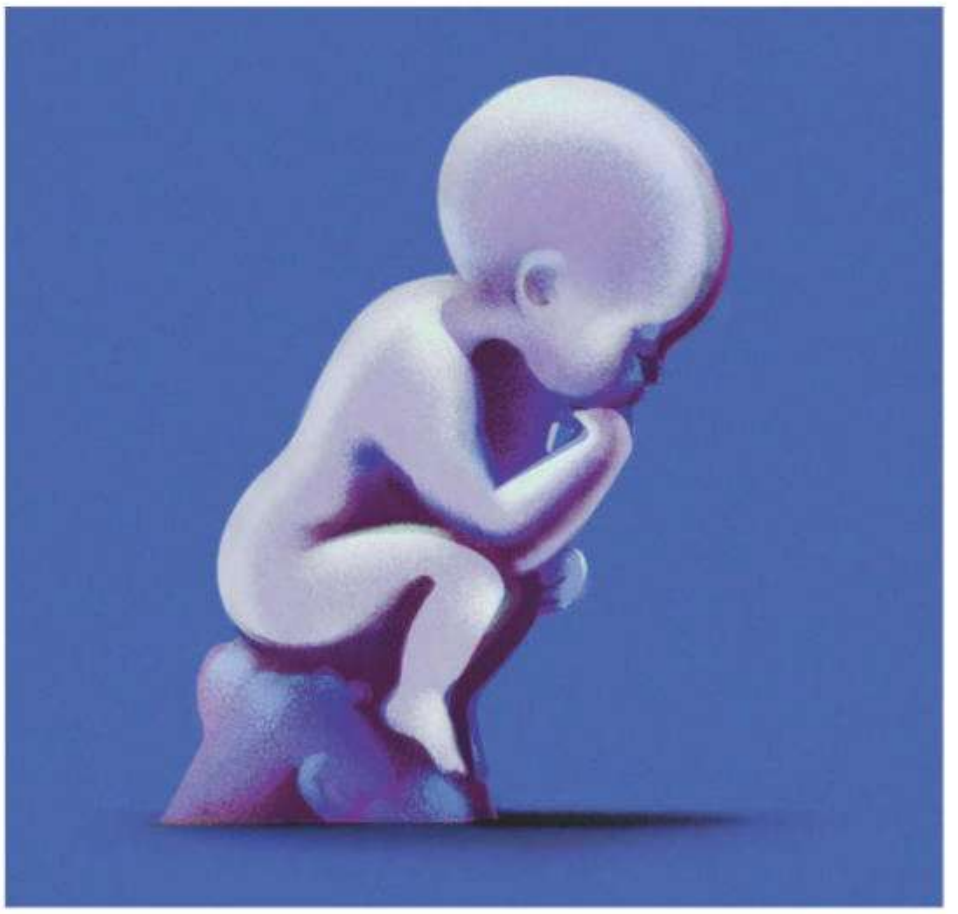
Evidence suggesting newborn infants perceive the world consciously has implications for their care, says **Claudia Passos-Ferreira**

DO NEWBORN babies consciously hear sounds and feel pain? In the past, infant boys undergoing circumcision were often not given anaesthetic, partly because it was thought that their brains were immature and they couldn't consciously feel pain. Even today, there remains much uncertainty. Babies cannot tell us what they are experiencing, so it is hard to know what they are conscious of.

Recently, neuroscientists have uncovered evidence suggesting newborn infants perceive the world consciously. When newborns encounter certain surprising stimuli, their brain reacts strikingly similarly to the way conscious adult brains react.

One method to investigate uses the oddball paradigm. First, you hear the same sound a few times in a row (like *be-be-be*). The next sound can either be another *be* or a different sound, like *bo*. When the final sound is different (*be-be-be-bo*), it surprises you because it breaks the pattern you were expecting, and your brain reacts with an electric signal, called the P300 wave, that reflects a violation of your expectations. This is known as a "local oddball" reaction.

In a more complex version, you hear a sequence like *be-be-be-bo* repeated several times and start expecting this pattern. If the sequence then changes to *be-be-be-be*, it surprises you again, and your brain again reacts with the P300 wave. This more complex change in the pattern is called a "global oddball" reaction.



ADRIÀ VOLTÀ

In adults, local oddball reactions occur even when they are unconscious. Sleeping adults and comatose patients can produce the P300 wave in response to local oddballs. The more complex global oddball reaction, however, only happens when adults are conscious, not when they are sleeping or anaesthetised.

As a result, the global oddball P300 reaction is sometimes used as evidence of consciousness in those unable to communicate verbally. The task requires people to keep track of complex patterns, and tracking these patterns seems to require consciousness. If someone emerging from a coma shows the P300 response to global oddballs, this indicates they might be conscious.

Studies show that 3-month-old infants have brain responses to global oddball stimuli, including a P300-like response. This suggests these infants detect both local and global oddballs. Another study found similar responses in awake newborns in the first week of life. Insofar as global oddball detection is a sign of consciousness, these results suggest that newborns are conscious of the stimuli.

What about consciousness before birth? Researchers have also applied the oddball paradigm to measure brain responses in fetuses. One study found fetuses after 35 weeks of gestation show a similar brain response to global oddballs. This suggests fetuses in the final weeks of gestation may be capable of consciously processing stimuli from outside the uterus. Any implications for the abortion debate are limited, as the results show evidence for consciousness only after 35 weeks, when abortions are very rare.

But there may be implications for areas such as infant care. If newborns can be conscious, they can also consciously experience pain. If so, they should receive anaesthesia for procedures such as circumcision. Similarly, if fetuses over 35 weeks of gestation can be conscious, we should take this possibility into account in fetal surgery and in childbirth to ensure appropriate pain management.

Infant consciousness is still poorly understood, but work like this shows it is possible to make progress. By applying insights from the science of consciousness in adults to infants, we may eventually have a scientific understanding of how infants experience the world. ▮

Hear more from Claudia Passos-Ferreira at our Instant Expert event in New York on 22 June

Claudia Passos-Ferreira is a professor of bioethics at New York University

This changes everything

An affair to remember

Nine years after hackers targeted Ashley Madison, the dating site for wannabe adulterers, here's what everyone still gets wrong about the scandal, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest book is *Stories Are Weapons: Psychological warfare and the American mind.* They are the co-host of the Hugo-winning podcast *Our Opinions Are Correct.* You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
Renée DiResta's Invisible Rulers*, a brilliantly researched book about online disinformation.*

What I'm listening to
404 Media's weekly news podcast, showcasing investigations into the hidden depths of the online world.

What I'm working on
Eating biang biang noodles as much as possible on my book tour.

This column appears monthly. Up next week: Rowan Hooper

IT HAS been nearly a decade since hackers dumped huge amounts of personal data from Ashley Madison, the infamous dating site which, back in 2015, catered mostly to men who wanted to cheat on their wives. Now, that story is back in the media, partly because of a recent Netflix documentary about it.

You can see me in that series, a nerdy talking head in clips from various TV news shows from 2015, because I was one of the journalists breaking the story. But neither the Netflix series nor the handful of other documentaries still in the works get at what was truly revolutionary – and chilling – about the Ashley Madison affair.

Generally, the media has focused on the (mainly) men whose names and desires were taken from the company's subscriber database and shared with the world. But that isn't a new story. People have been trying to have affairs with strangers for thousands of years. Ashley Madison was never really about that. Avid Life Media, its parent company, wasn't in the business of sex, it was in the business of bots. Its site became a prototype for what social media platforms such as Facebook are becoming: places so packed with AI-generated nonsense that they feel like spam cages, or information prisons where the only messages that get through are auto-generated ads.

After a rebrand, Ashley Madison is now owned by Ruby Life and bills itself as a spicy dating site for married people. But back then, it marketed itself as a social networking site for men seeking affairs with women. In late 2015, a group calling itself Impact Team got angry at the site and hacked into its servers. The group grabbed a bunch of user data and code, then posted it on Reddit with the claim that 95 per cent of the people on the site were men. I was intrigued. How could all those men be having affairs, if there were virtually no women on the site?

With the help of two hackers and a database expert, I decided to find out. What I discovered was a bizarre scam – though it was far more like *Westworld* than US reality show *Cheaters*. The company had systematically created an army of fake women, mostly very simple chatbots called engagers, who would flirt with men to lure them into paying for a subscription to the site. As I wrote in 2015, "it's like a science fictional future where every woman on Earth is dead, and some Dilbert-like engineer has replaced them with badly-designed robots". Back then, I repeatedly contacted Avid Life Media for comment, but it wouldn't reply.

"The new Netflix documentary series doesn't get at what was truly chilling about the Ashley Madison affair"

As we pored over the code, we found that, although there were a few human women on the site, more than 11 million interactions logged in the database were between human men and female bots. And the men had to pay for every single message they sent. For most of their millions of users, Ashley Madison affairs were entirely a fantasy built out of threadbare chatbot pick-up lines like "how r u?" or "whats up?"

There were real women behind the curtain, though. We found company emails in the data dump and discovered that Avid Life Media was also paying a small number of workers to generate fake profiles for more than 70,000 engager bots.

One of these workers sued the company in 2013, arguing that she had been required to type up so many fake profiles that she permanently injured her wrists (the lawsuit was dropped in 2015). It gets weirder: we found an internal email where employees discussed a tool they had built called fraud-to-engager, which automatically converted fraudulent profiles from other Avid Life Media sites into Ashley Madison bot profiles. "Should tweak it and rename it," one employee suggested.

At the time, I was shocked by the sheer number of fake women. I wrote: "Instead of looking at Ashley Madison as a dating site, I think it's more accurate to call it an anti-community—a hugely popular social site where it's impossible to be social, because the men can't talk to each other, most of the women are fake, and the only interaction available is with credit card payments."

Nine years later, this could describe any number of social media sites that have become swamped with bots and AI-generated absurdity – and charge you for the privilege of interacting with techno-phantoms. Currently, Facebook is trying to figure out how to deal with millions of fake images generated by AI, while Google's AI bot Overviews is telling users to glue cheese to pizza. The problem is, human beings are interacting with these AI images and suggestions, in some cases imagining they are engaging with real people.

It is like the whole world has become the Ashley Madison of 2015, and the more we want to talk to each other about it, the less likely we are to find a human to talk to. ▮

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"Progress made to operationalise the AMA so far must be commended."

Saba Berhane, Manager, Regulatory Affairs, IFPMA

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"Industry follows and may assimilate technological and conceptual advances from academic publications."

Philip Simister, PhD Head of Science and Entrepreneur Advocate, OBN (UK)

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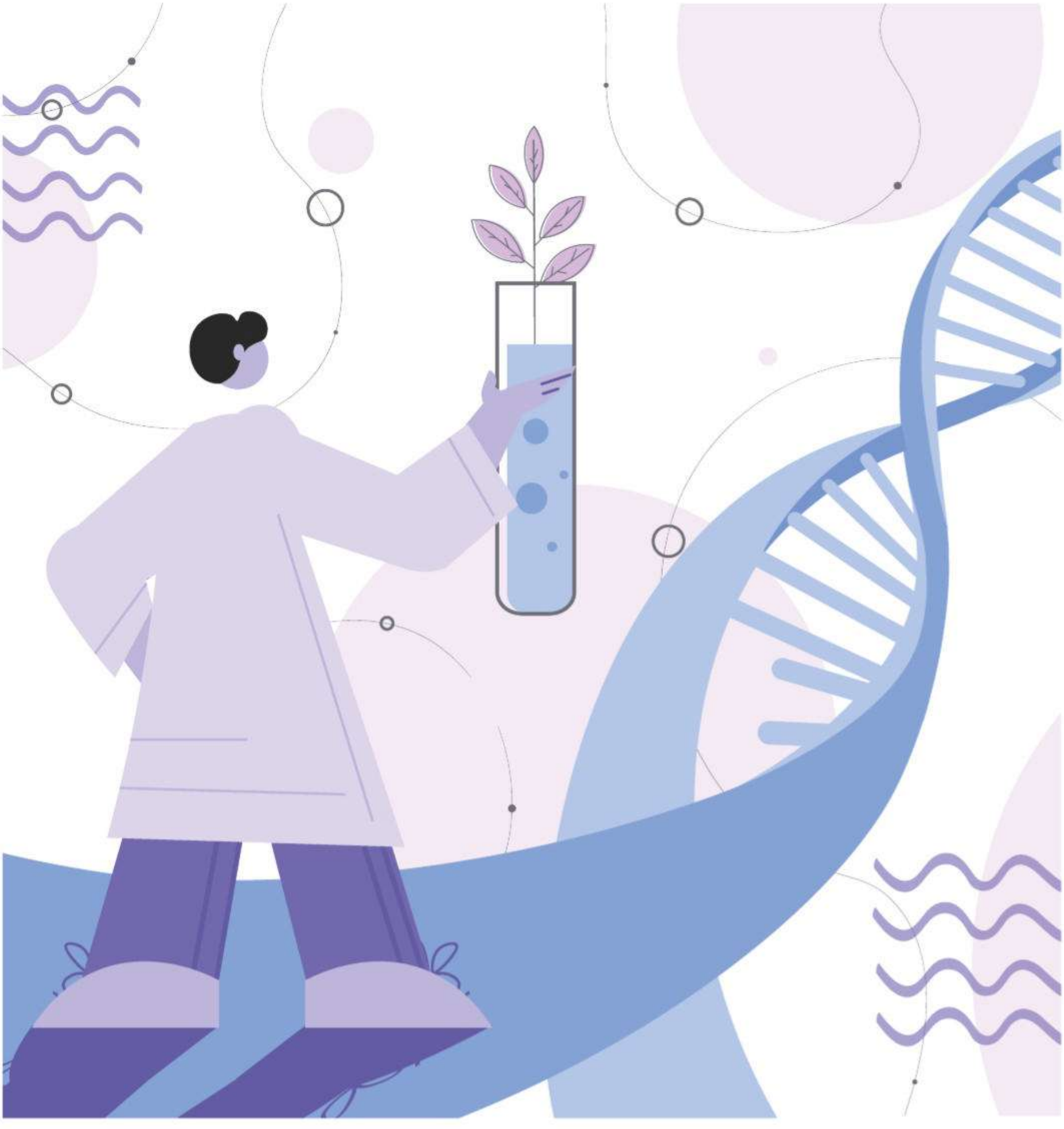

Reusable cartridges for laboratory water purification systems help cut waste

Launch of innovative filter cartridge boosts sustainability and offers cost savings for laboratories using ultra-pure water systems.

An innovation in ultra-pure water technology that reduces carbon emissions by up to 90% and saves users 20% on each filter cartridge, has been launched by laboratory supplies company Avidity Science.

Reusable cartridges boost laboratory efforts

"This new technology will help laboratories using ultra-pure water for research to achieve carbon reduction and reach sustainability goals while saving money," says Tim McDougle, Executive Vice-President, EMEA and Global Life Science Solutions. "The industry has been talking about reusable cartridges for 30 years, and now, they are here."

The company patented a new plastic cartridge design, which can be returned to them for reuse instead of being discarded for landfill. The cartridge is designed for use in the Avidity Solo™ S system, which includes a reusable metal-based alternative to activated carbon media, to produce up to 10L of Type-1 ultra-pure water daily from a tap water feed.

The industry has been talking about reusable cartridges for 30 years, and now, they are here.

Significant waste and cost reduction

The new cartridges contribute to plastic waste reduction and include an indicator that shows when they need replacing (typically after six months). Users joining the company's recycling scheme can return spent cartridges and receive replacements at a discounted cost.

McDougle says: "The typical life of an Avidity Solo™ S system is 10 years, and many laboratories have multiple systems. A user buying an annual pack of six consumables, for instance, would normally be buying 60 newly created cartridges a decade. However, using reusable cartridges can reduce that to 12."

Tim McDougle
Executive Vice President, EMEA & Global Life Science Solutions

WRITTEN BY
Linda Whitney

Paid for by **Avidity Science**

Read more at **avidityscience.com**

AVIDITY SCIENCE

Operationalising the African regulatory ecosystem for the **benefit of all patients**

Regulatory alignment across Africa can boost life sciences innovation, aiding pharmaceutical sector growth and enhancing patient access to medicines and vaccines.

For over a decade, significant progress has been made in strengthening Africa's regulatory ecosystem, led by initiatives such as the Africa Medicines Regulatory Harmonization (AMRH), World Health Organization and the African Union Development Agency-NEPAD, paving the way for the African Medicines Agency (AMA).

Enabling efficient regulatory collaboration

Through the development of common standards and regulations, this Agency could become one of the most efficient and modern regulatory systems in the world.

Its successful operationalisation would enable collaboration between national regulatory authorities, work-sharing and reliance procedures and mutual recognition of regulatory decisions. This would build regulatory capability and capacity, streamline processes and ultimately lead to timelier access to medicines and vaccines for African patients. It envisions a continent-wide regulatory environment on the continent.

Supporting a strong ecosystem

In particular, the AMRH continental technical committees have made tremendous efforts and progress to support its establishment. This includes the revision of the AU Model Law on Medical Products Regulation, the development of continental guidelines and procedures for the listing of medical products and the establishment of a continental infrastructure management system for the exchange of regulatory information.

The pharmaceutical industry is contributing technical expertise and experience with global regulatory standards while volunteering in regional pilot projects to optimise and shape new processes.

Transformed regulatory environment

This is pivotal for the healthcare landscape in Africa. An operational AMA, alongside a strengthened health workforce, will not replace regional and national regulatory authorities but leverage these to support a cohesive continental body. This will improve health outcomes in Africa and combat falsified and substandard medicines across the continent's health systems.

Amid digital transformation, these innovations also contribute to revolutionising regulatory processes, thus enhancing efficiency and sustainability. Progress made to operationalise the AMA so far must be commended, particularly the announcement of a Board in April. The critical next step is the appointment of its Director-General. Under their leadership, we can build on the foundations of the AMA and enable an African regulatory environment that benefits all patients.

Saba Berhane
Manager, Regulatory Affairs, IFPMA

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Catalysing entrepreneurial growth: from university niche to industry ecosystem

Historically, there was more division between academia and industry, but they now collaborate more effectively. University research, especially in life sciences, frequently impacts industrial research and development (R&D).

Philip Simister
PhD, Head of Science and Entrepreneur Advocate, OBN (UK)

Industry follows and may assimilate technological and conceptual advances from academic publications, combined with proprietary know-how, to improve industrial R&D workflows.

IP development for societal impact

A natural extension to a key mission of universities — to create and disseminate reliable knowledge — is developing their intellectual property (IP) for broader societal impact. Translating academic research directly into real-world outcomes is patently desirable for industrial investors, yet more recently so for original grant funders (eg. charities, government). This can amplify patient and societal benefits while creating jobs and economic gains for individuals and organisations.

Possible perceived obstacles within academia to technology transfer — such as lack of experience/will/time, limited business understanding or apparent conflict with traditional academic purpose — should be surmountable through education and mentoring to develop better business mindsets and acumen. Many institutes promote such practices, but more widespread adoption is needed.

Supporting research commercialisation

Multiple mechanisms exist to support UK universities and emerging entrepreneurs in commercialising research and engaging with a well-established industrial ecosystem. The Innovate UK ICURe programme helps academics to evaluate the commercialisation potential of their research.

The University Spin-Out Investment Terms (USIT) guide (TenU, 2023) offers an efficient time and cost-saving framework for university spin-off creation, allowing adaptability to individual company-building scenarios. Investment firms engage increasingly with research institutes to identify potential IP early. To stimulate entrepreneurship further, grant funding providers could require academics to assess upfront any commercialisation potential of research findings, where relevant.

Beyond the technical aspects of company creation, for example, emerges the more ethereal concept of network-building for success. Clear communication is key to successful collaboration, and building an effective niche for a NewCo within an existing ecosystem requires high, initial effort.

Life sciences organisations' impact

Life sciences member organisations, including OBN (UK), function as network builders. They help modulate ecosystemic forces impacting spinouts such as by reducing barriers to ecosystem entry and facilitating the rate and effectiveness of business-enhancing interactions. This 'catalytic' activity can, ultimately, also save companies time and money.

Read more at **obn.org.uk**

How new research centres will unlock more rare disease tests and treatments

Four new research centres are set to unite scientists and specialists across the country to develop new tests and treatments for patients with rare diseases.

For patients with rare diseases to benefit quickly from new treatments, researchers and scientists from various disciplines and facilities must collaborate more closely.

Rare disease research requires collaboration

Unfortunately, the field of rare disease research can often be fragmented. Self-funded, medical research charity LifeArc points out that scientists can lack access to specialist facilities, advice on regulation, trial designs, preclinical regulatory requirements and translational project management. Consequently, delivery of treatments from bench to bedside can be devastatingly slow.

"I think everyone in this field would agree that better collaboration is needed," says Dr Catriona Crombie, Head of Rare Diseases at LifeArc. "Rare diseases are challenging precisely because they are rare; there are no rare disease-specific conferences and academic societies where researchers can gather to discuss their latest findings."

Encouraging collaboration between leading scientists

In response, LifeArc has invested £40 million into launching four new virtual research centres in the UK — hosted by four lead universities — to improve tests and treatments for people with rare diseases. These are the LifeArc Centre for Rare Respiratory Diseases; the LifeArc-Kidney Research UK Centre for Rare Kidney Diseases; the LifeArc Centre for Rare Mitochondrial Diseases; and the LifeArc Centre for Acceleration of Rare Disease Trials.

The centres will unite leading UK scientists and rare disease specialists for the first time, fostering new interdisciplinary collaborations and enhancing access to facilities and training.

Funding awarded for rare disease research

Each centre has been awarded funding because it holds real promise for delivering change for people living with rare diseases, notes Dr Crombie. "We've invested in areas where there is significant unmet need, but where enough of the fundamental science is understood for diagnostics, drugs or interventions to be helped through the translational pathway," she explains.

Scientists, academics and researchers across the centres are excited to work together. "We're optimistic that the centres will facilitate more rare disease research in the UK and help it move at a faster pace," says Dr Crombie.

Dr Catriona Crombie
Head of Rare Diseases, LifeArc

WRITTEN BY
Tony Greenway

Scan the QR code to find out more

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Linda Bedenik
Senior Policy and Public Affairs Manager, BioIndustry Association (BIA)

The UK's biorevolution: how 'Deep Biotech' is leading the way for sustainability

Advancements like CRISPR gene editing, big data and AI analysis, genomics breakthroughs and DNA sequencing industrialisation are driving major changes in biotechnology.

The rise of modern industrial biotechnologies enabling us to engineer biology is leading us down a path of truly disruptive biological innovation that can tackle many of the UK's and global sustainability threats if widely implemented.

Deep Biotech creating sustainable UK bioeconomy

The BioIndustry Association (BIA) has named this frontier of science — and the innovative companies leading it — Deep Biotech. Our brand-new report, 'Deep Biotech: Disruptive innovation for global sustainability' highlights how Deep Biotech is key to creating a sustainable UK bioeconomy and making the UK a science superpower that benefits all.

We are already witnessing the rise of this biorevolution. UK startups optimise algae to transform CO_2 into biofuels, use soil to grow sustainable packaging, grow meat in bioreactors, not on valuable land, and craft enzymes that eat plastic.

Biomaterials: creating better materials

The fashion industry is estimated to be causing 10% of global carbon emissions. Polyester, largely derived from petroleum, dominates 54% of the global market due to the competitively low price of fossil fuels. Novel biomaterials have the potential to reduce our reliance on animal and petrochemical-derived materials in the future.

Advances in the development of biomaterials can replace some synthetic, petrochemical-derived fibres and prevent the pollution of water through microfibre shedding more generally. Globally, 16% and 35% of microplastics released into our environment are from the laundering of synthetic textiles, which can end up in the food chain and, ultimately, the human body. Once released, they are difficult to remove from the environment.

The fashion industry is estimated to be causing 10% of global carbon emissions.

Seizing the Deep Biotech opportunity

While the impact-driven nature of Deep Biotech is easy to grasp, its interdisciplinarity will require understanding and support across government. Elections are looming, and the task for our incoming government will be to seize the opportunity and realise biotech's potential across our entire economy and society. With the UK's track record of success in health biotech, we are well-placed to ignite the biorevolution — from the medicines we take to the food we consume and the clothes we wear.

Developing drug discovery initiatives for Africa, out of Africa

Dr Susan Winks
PhD, MBA; Head of Research Operations and Business Development at University of Cape Town Holistic Drug Discovery and Development (H3D) Centre

Prof Kelly Chibale
Neville Isdell Chair in African-centric Drug Discovery and Development, Founder and Director, University of Cape Town Holistic Drug Discovery and Development (H3D) Centre

We must develop drug discovery research capacity near patients in Africa to understand and meet their health needs. Africa's emerging drug discovery community is poised to tackle these challenges.

Africa, home to 1.3 billion people, faces a triple health threat from infectious diseases, non-communicable diseases and socioeconomic challenges that exacerbate access to healthcare.

Need for innovation ecosystem in drug discovery in Africa

The Holistic Drug Discovery and Development Centre (H3D) is a case in point. It has achieved remarkable milestones as Africa's first integrated drug discovery centre. Founded in 2010 and accredited by the University of Cape Town (UCT), H3D has established a world-class integrated drug discovery infrastructure and delivered Africa's first clinical candidate for malaria, showcasing the potential of Africa-led research.

Beyond its pioneering work in malaria, the Centre has developed a diverse drug discovery portfolio covering multiple disease areas. Starting in 2018, the Bill & Melinda Gates Foundation (BMGF), in partnership with the Grand Challenges Africa programme, funded 16 drug discovery pilot projects across seven African countries with active support from H3D. This laid the foundation for a new community of practice.

In 2023, with a further investment of $7.2 million from BMGF and LifeArc, this emerging community established four pan-African drug discovery flagship projects and formally initiated the Grand Challenges African Drug Discovery Accelerator (GC ADDA) network.

Building sustainable solutions

At its core, GC ADDA exemplifies the power of collaboration. By bringing together researchers with complementary capabilities, expertise and a common vision, GC ADDA focuses on diseases prevalent in Africa. It aims to leverage existing expertise and facilities to establish a pipeline of drug discovery projects, delivering optimised leads and high-quality drug candidates.

For sustainable and impactful change, GC ADDA will work to establish regional centres of excellence to support and train the next generation of African drug discovery researchers. A key element of the strategy is building connections with the global research community, including the African diaspora, to accelerate impact.

It is a strategic imperative to encourage African academics to champion such initiatives tackling the pressing health issues that confront the continent. Together, we can unleash the full potential of drug discovery in Africa for a brighter future.

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Editor's pick

Here's why humans really evolved stamina

18 May, p 11

From Howard Bobry, Port Townsend, Washington, US

The idea that humans evolved endurance and stamina to chase prey might have it backwards. Prior to the development of sharp tools, we were ill-equipped to consume prey animals, lacking, as we were, the teeth and claws of a carnivore. Our early ancestors were gatherers, not hunters. It was us who were the prey, and our survival depended upon our ability to outrun not the predator, but our fellow humans.

If you and I, out gathering, were approached by a lion, I wouldn't need to outrun the lion to survive, only you. Survival of the fittest at its most basic level!

Processed foods: addiction or just clever marketing?

25 May, p 10

From Talia Morris, Cape Tribulation, Queensland, Australia

You discuss the idea that food addiction might be akin to drug addiction. This idea overlooks the fact that ultra-processed foods are designed to be over-consumed. They are visually appealing, intensely flavoured, energy dense goodies that beg sensory seeking while providing little satisfaction. These factors strongly encourage people to eat more of them than is reasonable. When people do so, they are as much victims of marketing as addiction. Penalise the makers, not the consumers.

We need a new name for addiction

Leader, 25 May

From Martin Sigrist, Newbury, Berkshire, UK

I agree that the term "addiction" isn't sufficiently precise to be used in a scientific context. It would be better to have something that gets to the heart of why addiction may be a problem in some cases to some people and not in others. Something along the lines of "harmful, unregulable dependency" perhaps.

From Terry Klumpp, Melbourne, Australia

Addicted? Who? Me? Yes! I am addicted to *New Scientist*! I crave its stimulating food for thought! I can't live without it! I can hardly wait for the next edition.

Orchids may be sharing food with many species

25 May, p 16

From Rachel Mckeown, Cambridge, UK

Although I see the potential for orchids to transfer food to seedlings via a fungal network, the study you describe reminds me of a limitation in experimental design – namely, that reducing complexity can give only a narrow window into a real-world ecosystem. I imagine a real mycorrhizal network doesn't link up with a single orchid species, and if the fungus is actually in control of nutrient distribution, how can orchids ensure that food they input safely finds its way to others of the same species? Perhaps the symbiotic relationship actually involves several species inputting nutrients to the network, which pools them and distributes them.

Where to draw the line in a neurodiverse world

25 May, p 39

From Richard Grimmer, Trowbridge, Wiltshire, UK

Grace Wade highlights an important point in her article on neurodiversity. The human race is diverse; every brain develops differently. So how do we make sure terms like "neurodiverse" are only applied to those who would benefit from such labels? How do we ensure that the neurotypical population gets the meaning and implications of such terms?

Perhaps a better bet would be "neuro-atypical". This would highlight to educators that these children would flourish under atypical teaching methods, and to employers that these employees would have different ways of working and different needs.

Farming emissions aren't inevitable

25 May, p 12

From Cheryl Hillier, Lampeter, Ceredigion, UK

Again and again we read that some carbon emissions from agriculture are unavoidable. This view keeps resurfacing despite the best efforts of agroecologists, who will say that if we remove fossil fuel-intensive artificial fertilisers and farm in ways that support nature, instead of poisoning it, farming becomes carbon negative.

Thinking even more about thought

25 May, p 33

From David Werdegar, Naperville, Illinois, US

I have an extra point to raise on how to think about thought. It is that thought can't exist without language. Pre-language actions depended on internal and visual associations in the brain. Imagine a hominid waking with hunger pangs in her tree long ago. She looks around and sees fruit in another tree. Eating fruit and hunger reduction are strongly associated in her brain. She leaps across and has breakfast. If you think you can have thoughts, simple or complex, without language, try it. You will find it frustrating as well as instructive.

Rational action economic theories are a dying breed

18 May, p 15

From Stephen Johnson, Eugene, Oregon, US

You reported on a game theory simulation that showed people failed to reach a state of rational action, even after multiple failures and repeated feedback. This was said to be in variance with economic theories. However, the result is in line with over 50 years of research by psychologists on micro-economic decision making.

Studies by Paul Slovic and Daniel Kahneman, plus others, show that judgmental heuristics and biases work to prevent rational economic behaviour. Very few economists today believe in rational human action economic theories.

It is quality, not quantity, that counts

Letters, 25 May

From John Byrne, Perth, Australia

I disagree that a steady decline in world population will hinder progress, provided we reach and maintain a sustainable level. Population in the year 1905 for Albert Einstein's work was a fifth of today. In the 1960s, when we went to the moon, it was less than half its current level. It is quality and sustainability of civilisation and the environment that counts, not sheer weight of numbers.

Cake tin is two slices short of a full load

Letters, 25 May

From Ben Crossley, Wigston, Leicestershire, UK

A 200-square-inch cake tin of the dimensions given by Keith Walters (14.14 inches per side) only allows 98 slices exactly 1 inch by 2 inches. Unless you somehow combine the bits left round the edges. ▮

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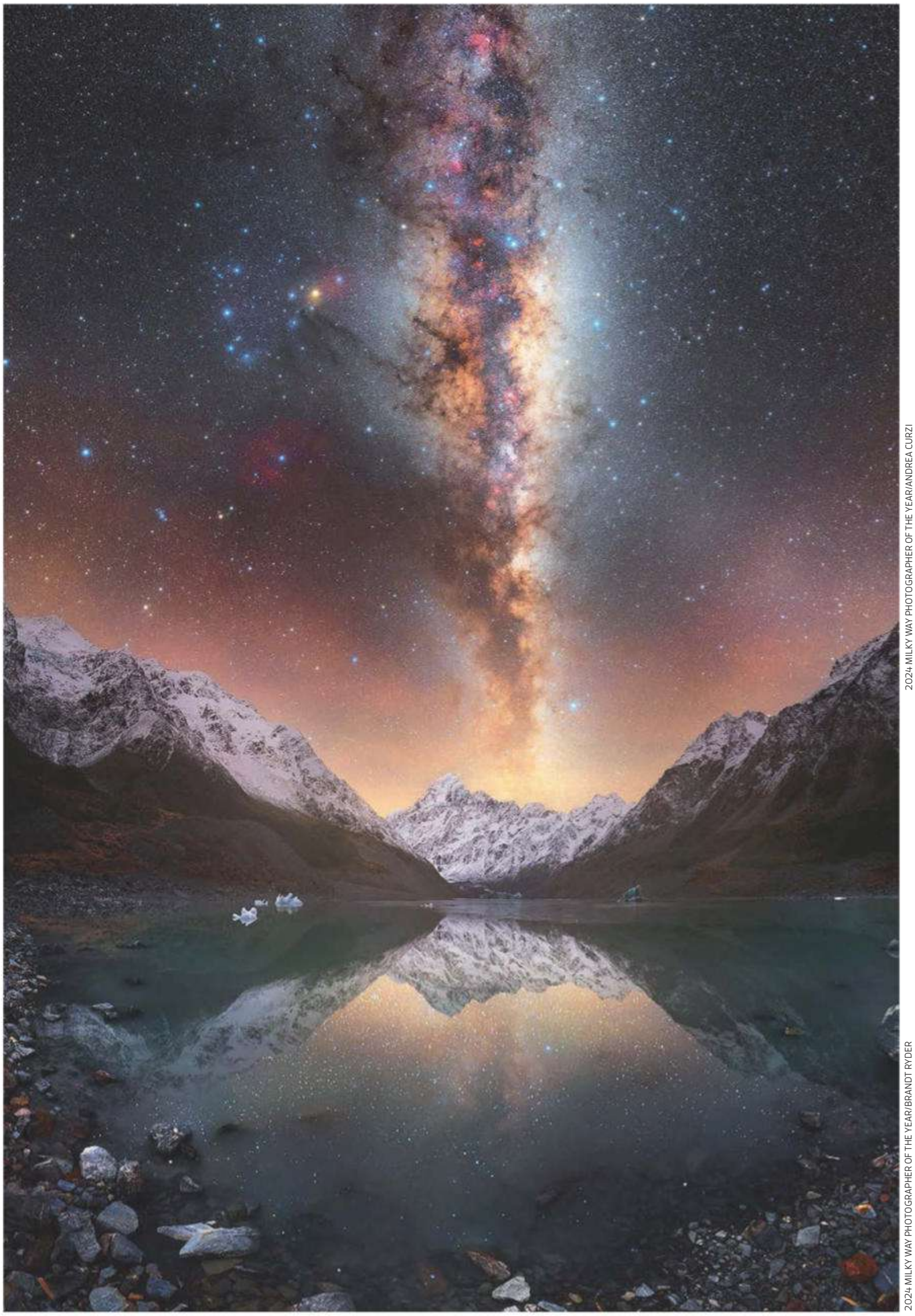

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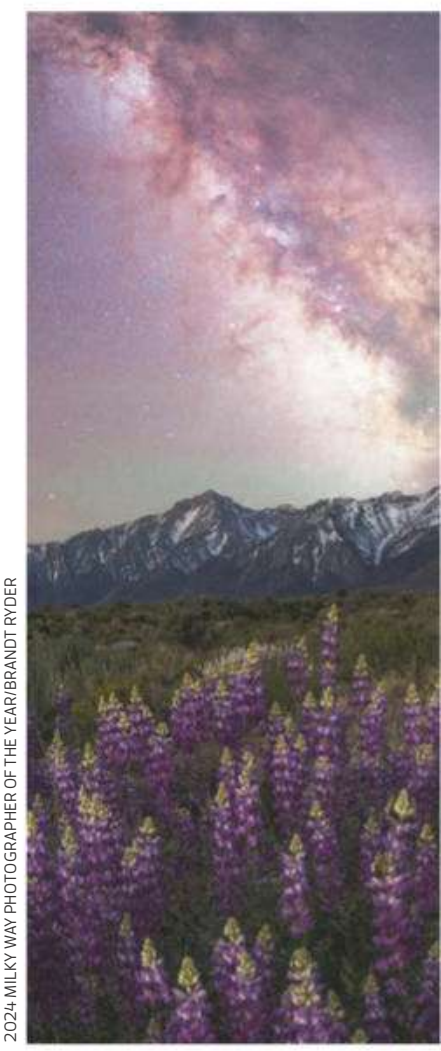
2024 MILKY WAY PHOTOGRAPHER OF THE YEAR/ANDREA CURZI



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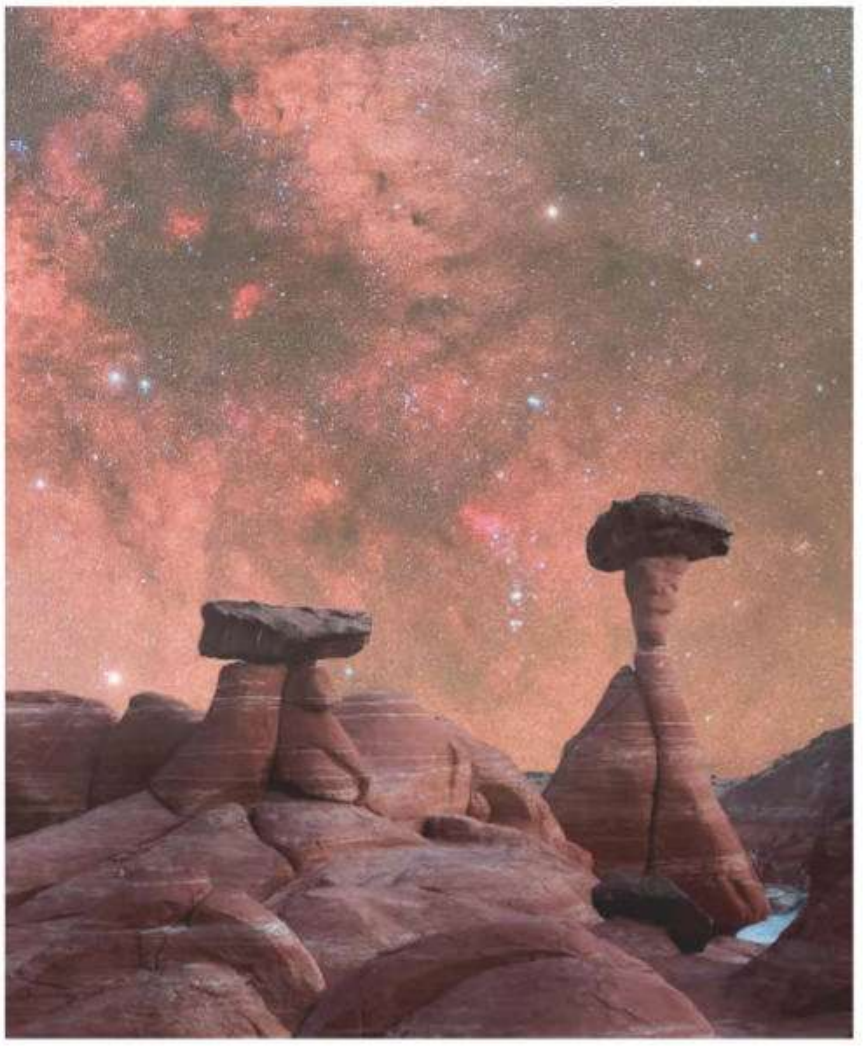
Spot the galaxy



2024 MILKY WAY PHOTOGRAPHER OF THE YEAR/STEPHANIE THI

Capture the Atlas

IN THE right place at the right time, cast your eyes to the sky and you may see something awe-inspiring.

This is the feeling evoked by these images, a few of the winners of this year's Milky Way Photographer of the Year competition. Each year, the top 25 spellbinding shots of our galaxy, captured from prime spots around the world, are curated and published by Dan Zafra, editor of travel photography blog Capture the Atlas.

Tom Rae's entry, at far left, shows the Milky Way emerging from New Zealand's highest mountain, Aoraki/Mount Cook, on a winter's night. "In rare alpine weather conditions, I embarked on a journey up the glacial valley one night," said Rae in an announcement on Zafra's site. "Upon reaching the lake, the scene that unfolded made me feel like I had landed on another planet."

In another elevated endeavour, Matej Mlakar captured an "arch" of the Milky Way (top right) over Vršič Pass – the highest mountain pass in Slovenia. The red blurs in the sky are clouds of glowing hydrogen called emission nebulae, which appear red due to emitting only at particular wavelengths. The light is produced due to the ionisation of atoms in the gas, caused by newly forming stars.

Meanwhile, the smaller images show remarkable scenes from the US. Brandt Ryder's shot, farthest left of the two, was taken in the Eastern Sierra region of California, where the Milky Way frames a violet sea of lupines. Stephanie Thi named her image, taken in Utah, *Starry Hoodoo Wonderland* – a nod to the toadstool-like hoodoo rocks that add to the aura of her starry backdrop.

Gege Li

Who wants to live forever?

A new exhibition explores the possibilities and pitfalls of living healthily for centuries – or at least much longer than today, says **Alexandra Thompson**

Exhibition

The End of Aging
Michael Schindhelm
Kulturstiftung Basel H. Geiger, Switzerland, to 21 July

KULTURSTIFTUNG BASEL H. GEIGER/KBH.G

A woman laments her artificially long life in part of an installation by film-maker Michael Schindhelm (below)

"All diseases run into one, old age," wrote the 19th-century essayist Ralph Waldo Emerson. While ageing isn't considered a condition in its own right, our risk of developing everything from cancer and dementia to heart disease and arthritis grows greater with every passing decade.

Ageing is also generally associated with a decline in quality of life, as a fall in energy levels coincides with new aches and pains. Little wonder that the concept of anti-ageing has inspired legends and literature for centuries, from the mythical "fountain of youth" to Oscar Wilde's *The Picture of Dorian Gray*.

In one of the latest artistic endeavours, Michael Schindhelm explores the concept of defying old age. His immersive installation *The End of Aging* in Basel, Switzerland, is the first of two exhibitions on ageing in the Kulturstiftung Basel H. Geiger centre. He became interested in longevity during the 1990s, when the arrival of electronic prosthetics started to merge human and machine.

Decades later, the rapid development of the covid-19 vaccines – covered in his documentary *A Vaccine at the Speed of Light* – left him wondering about our biomedical future.

Longevity is certainly having a moment, partly thanks to the high profile of people like billionaire Bryan Johnson, who is attempting to defy the years by taking copious supplements, undergoing plasma infusions and seemingly measuring his body's biomarkers.

But Schindhelm's take on a longer life makes you wonder if it is worth the bother. His five-room exhibition opens by simulating a disused hospital ward, complete with the stale, musty odour of abandonment. You may be thinking, if it were standard for humans to live a century or more, surely hospitals would be heaving?

But the quest isn't merely to reach the ripe old age of, say, 150, it is to do so in good health, without the need for medical care. As a scientist character booms from a screen along the wall: "We should all die young after a long life."

A decrepit corridor takes you to an old laboratory, a control room and an operating theatre, complete with figurines of radioactive rats, adding to the feeling of dystopia. The operating theatre features a screen where a fictional and seemingly young woman talks of suicide, desperate to escape her prolonged life.

But what are the actual chances of vastly extending our lives? In reality, few drugs have good-quality evidence to support a longevity-boosting effect. Perhaps the best exception is rapamycin, originally developed as an immune-suppressing drug for people undergoing organ transplants. One study found it extends the lives of mice by up to 60 per cent by dampening a cell signalling pathway.

Running trials in people is more challenging, not least because they would require decades-long follow-up. Rapamycin is also off-patent, leaving pharmaceutical companies with little incentive to test its life-extending effects.

KULTURSTIFTUNG BASEL H.GEIGER/KBH.G

Developing new treatments runs into the same roadblock. "As long as ageing isn't considered a disease, no authority will approve such a drug, so why invest billions into a trial," says Schindhelm. Case in point, a study that seeks to test whether the diabetes medication metformin delays age-related conditions has so far only received funding from philanthropists.

The hypothetical world depicted in the installation largely focuses on the negatives of a society full of centenarians. Through a series of dramatic video clips, various characters ask what this would mean for our planet's health, with overpopulation contributing to the consumption of resources that drives climate change.

And with fewer people of working age, how would all the pensioners be supported? Would we reach our full potential – or even enjoy life – knowing we almost certainly have many decades ahead? On the flip side, more time on Earth means more opportunities to travel, more books to read, more wine to drink – indeed, more art to see.

The installation closes with a recovery room, where 10 (real) scientists offer what Schindhelm calls a "reality check" on how they expect the anti-ageing field to evolve, recounted in a 65-minute film that you watch while reclining on a hospital bed.

Schindhelm never seems to settle on whether he is exploring the idea of living forever or merely decades beyond our current life expectancy, about 75 to 80 years in high-income countries.

If he intends the former, Markus Rüegg at the University of Basel is unequivocal in rejecting that possibility. In the documentary, he says: "Nature is not built for eternity. I think

we can't fight biology in the end."

At the age of 63, Schindhelm has no desire to be immortal, but says he wants to see people having "a graceful last period of their life", without discomfort. The scientists are fairly unanimous about how to achieve it, with recommendations that are also age-old: eat well, exercise regularly, don't smoke, drink alcohol in moderation and stay socially connected. "You can do more for your longevity than a pharmacy," says Schindhelm.

The advice seems sensible, if unoriginal, but becoming a centenarian may not be entirely in our hands. "If you want to reach the age of 80, you have to have a healthy lifestyle," says Christoph Handschin, also at the University

"Would we reach our full potential – or even enjoy life – knowing we almost certainly have many decades ahead?"

of Basel, in the documentary. "You want to become 100, you also need the right genes."

Future generations may laugh at this kind of statement, or perhaps lament the impact of today's longevity movement. As to whether the installation's doomy perspective materialises, a lack of research on humans means we can't be sure which drugs or interventions will add decades to our lives, let alone what this could mean for our environment and society. When it comes to boosting our lifespan, "there's a lot of science, a lot of hype and a lot ofhope", says Schindhelm. ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org); US 988 Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for other countries

The DNA hunter

Eske Willerslev's story is as compelling as the DNA he found, finds **Davide Abbatescianni**

Film

Hunt for the Oldest DNA
Niobe Thompson
PBS

EMBRACING failure leads to experience and, ultimately, extraordinary achievements. This is at the heart of Niobe Thompson's documentary *Hunt for the Oldest DNA*, which premiered at the Copenhagen International Documentary Film Festival this year.

The film follows Eske Willerslev, a Danish evolutionary geneticist now at the University of Cambridge, whose team managed to reconstruct from ancient DNA the ecosystem that existed 2 million years ago in the Kap København Formation, northern Greenland. The area today is Arctic desert with few organisms, but back then it was a forest inhabited by reindeer and other species, perhaps even camels.

Yet as the documentary shows, Willerslev's success was hard-won. "I was a school failure, that's the truth," he says, explaining how years before he had been a desperate boy wrestling with his mental health. But he found a way through and, a few years on, we see him head the pioneering team of scientists out to sequence the oldest DNA.

Former anthropologist Thompson provides Willerslev with space to dig deep into his private life and his discoveries, which started with expeditions to Siberia in the early 1990s with his twin brother, Rane.

Roughly shot scenes are juxtaposed with beautifully animated flashbacks, as well as interviews during which Willerslev is an open book, and a very interesting one. The insight that took him on his epic hunt to Greenland started one rainy day, as a student at the University of Copenhagen, when he saw a dog defecating. He wondered (as you do) if some DNA might be left in the faeces or on the ground – and for how long.

In one of the film's most touching sequences, Willerslev reveals that curiosity plays a big part in scientific work, but that it isn't his main drive. "I've always had this need for winning. By winning, I'm keeping away my demons," he says.

***Hunt for the Oldest DNA* is a jewel of a film, an engaging tale about work-life balance and mental health that tugs at our hearts but also provides a unique learning experience. It loops in complex theories and concepts – the DNA double helix, evolution and how our planet is endangered – exploring them all in a playful fashion.** ▮

Davide Abbatescianni is a film critic based in Rome.

Eske Willerslev out on fieldwork at Ilulissat Icefjord, Greenland

HANDFUL OF FILMS INC

New Scientist *recommends*

Joshua Howgego
Deputy head of features
London

I am a podcast addict and my current favourite is **Past Present Future**, with David Runciman. It is about the history of ideas, and Runciman's mellifluous tones guide us through an eclectic

mix. There is plenty of science, including a recent episode on why taxonomy might have been a bad idea. I was sceptical, but ended up partly persuaded.

My favourite episode looked at *Gulliver's Travels*, a book I thought I knew. But I didn't realise that, as well as visiting Lilliput, Gulliver goes to Balnibarbi, a land where its inventors work on wild projects, like how to extract sunbeams from cucumbers. Runciman wonderfully unpacks the layers of meaning in this clever satire of the Royal Society.

I also love **The Chosen**, a TV series that richly imagines the lives of the disciples of Jesus Christ. As a science journalist and a Christian, I do think about the intersection of faith and evidence, and find it fascinating to see politics, power and (dis)belief collide as Jesus works his miracles.

The TV column

Stuck fast

The Leftovers follows those left behind after 140 million people vanish, unaccountably, in the Sudden Departure. The parallels with the covid-19 pandemic are painfully obvious in this jewel of a TV show, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on X @inkerley

VAN REDIN/HBO

Nora Durst (Carrie Coon) and Kevin Garvey (Justin Theroux)

IT IS a strange time to watch *The Leftovers*, which premiered on HBO 10 years ago this month. The series opens three years after the Sudden Departure, when about 140 million people (close to 2 per cent of Earth's population) just disappeared. Those left are still grappling with why and how to move on from such loss.

In the real world, it has been about three years since the last covid-19 lockdown lifted in the UK and many other countries. This was commonly seen as a return to some form of normality. We are now at a similar remove from the peak of our crisis as police chief Kevin Garvey (Justin Theroux) is from the Sudden Departure.

But Kevin's life is far from normal. He sees things that may not be real, like a stranger shooting packs of rabid dogs, and blacks out for long stretches. His wife Laurie (Amy Brenneman) has joined the Guilty Remnant, a cult seeking to prevent people from making peace with the tragedy, while his son Tom (Chris Zylka) follows Holy Wayne (Paterson Joseph), who claims to be able to remove people's pain entirely. His daughter Jill (Margaret Qualley) is one more fatalistic teenager in the crowd.

While the Garveys are relatively untouched by the Sudden Departure, one woman, Nora Durst (Carrie Coon), is deified in their town because her husband and children all disappeared. The Garveys are, however, still scarred by living in a world where the rules can be rewritten at a moment's notice, where people they love can be ripped from them in ways that seem to defy logic.

> **"*The Leftovers* is television of the body, not the brain. It invites you to feel before you think"**

The Sudden Departure was instant, random and had a far greater toll than the pandemic. But like the Garveys, many of us are still unable to fully reckon with the world our own crisis has left us in. How often do you think about covid-19 or the 7 million people it has killed? Is lingering on such thoughts the rational response to a disaster that could happen again or a maladaptive impulse that prevents society from moving forward? Is it even possible to find a middle ground?

Such questions filled *New Scientist* in the first couple of years of the pandemic. In that sense, watching *The Leftovers* could hardly be more timely as we consider how to acclimatise to pain and ruin, be it mass trauma or environmental degradation. And it is full of other questions that define our times: what drives us to extremism? Why does religious faith persist? And what happens when science seems to fail us, however temporarily?

Artistically, *The Leftovers* deserves your attention because it represents the peak of a golden age of television, an era sadly ended. It is everything we now revere about prestige TV: it is beautifully acted, written and scored, and it explores complex moral and existential ideas.

But the show also takes big risks: it is brilliantly ambitious and surreal, unwilling to talk down to its audience or provide easy answers. It plays with solving its central mystery, but largely resists explanations, unlike the countless "puzzle box" TV shows inviting viewers to predict finales, typically with disappointing results.

The Leftovers is television of the body, not the brain. It isn't an unintelligent series, far from it, but it invites you to feel before you think – a valuable and cathartic thing. If you can handle revisiting the lessons of the past few years – or just want great TV – I advise you to sit with the show and bear its full, terrible weight for a while. ▮

TV

The Leftovers
Damon Lindelof and Tom Perrotta
HBO

Bethan also recommends...

TV

Twin Peaks: The Return
David Lynch and Mark Frost
Paramount+
Nobody does it better than David Lynch. Twenty-five years after the original series ended, this revival gave us more fantastically unsettling imagery to dissect.

Lost
Damon Lindelof
Disney+
Before The Leftovers*, writer Damon Lindelof co-created the ultimate mystery series. For all its faults,* Lost *is as engaging and emotional in 2024 as it ever was.*

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Inside the event horizon

Are singularities, where physics breaks down, always hidden within black holes? Attempts to find out are revealing clues to the quantum origins of space-time, finds **Thomas Lewton**

DEEP inside a black hole, the cosmos gets twisted beyond comprehension. Here, at some infinitesimal point of infinite density, the fabric of the universe gets so ludicrously warped that Albert Einstein's general theory of relativity, which describes how mass bends space-time, ceases to make sense. At the singularity, our understanding falls apart.

As daunting as singularities are, each one is at least safely tucked away inside the event horizon of a black hole, the boundary beyond which we can't see. This not only cloaks them from view, but also stops unknown effects they herald, namely the horrors of unpredictability, from leaching out into the wider universe. But what if singularities could exist outside black holes after all?

That question, given fresh impetus in recent years by demonstrations that general relativity allows for this, has spurred theorists to probe singularities from a deeper perspective, folding in insights from the latest forays into the possible quantum foundations of gravity. Already, they are realising that this new approach "flips the script" on how we think about singularities, says Netta Engelhardt at the Massachusetts Institute of Technology.

Fair warning: the work takes us into some labyrinthine physics. But by grappling with singularities in this way, Engelhardt and her colleagues are deciphering the enigmatic connections between the quantum realm and classical gravity – and reinforcing the revolutionary idea that the latter emerges from the former like a holographic projection. "There's a lot that's hanging in the balance," says Engelhardt.

Soon after general relativity was published in 1915, physicists began finding solutions to its equations in which an incredibly dense ball of matter warps space-time so much that it plunges towards a point of infinite density and curvature. These are the singularities that have plagued the theory ever since.

The trouble is that no one knows how to interpret what these infinities really mean in the physical universe. "Mathematically, we start losing control," says Lisa Yang, also at MIT. In that sense, relativity, our best theory of gravity, appears to predict its own failure. The hope is that some new physics will come along and show us what we are missing, presumably involving quantum theory, which describes the behaviour of atoms and particles.

Inescapable mystery

"'What is the singularity?' is a daunting question," says Evita Verheijden at Harvard University's Black Hole Initiative. "We don't know what they are, we fundamentally don't know how to describe them."

No wonder many cosmologists initially hoped that singularities would turn out to be nothing more than a theoretical figment. Unfortunately for them, in 1965 the luminary cosmologist Roger Penrose proved that they are, in fact, an inescapable consequence of general relativity, occurring whenever matter collapses to form a black hole. "Singularities are ubiquitous," says Engelhardt, an insight for which Penrose eventually won a share of the Nobel prize in physics.

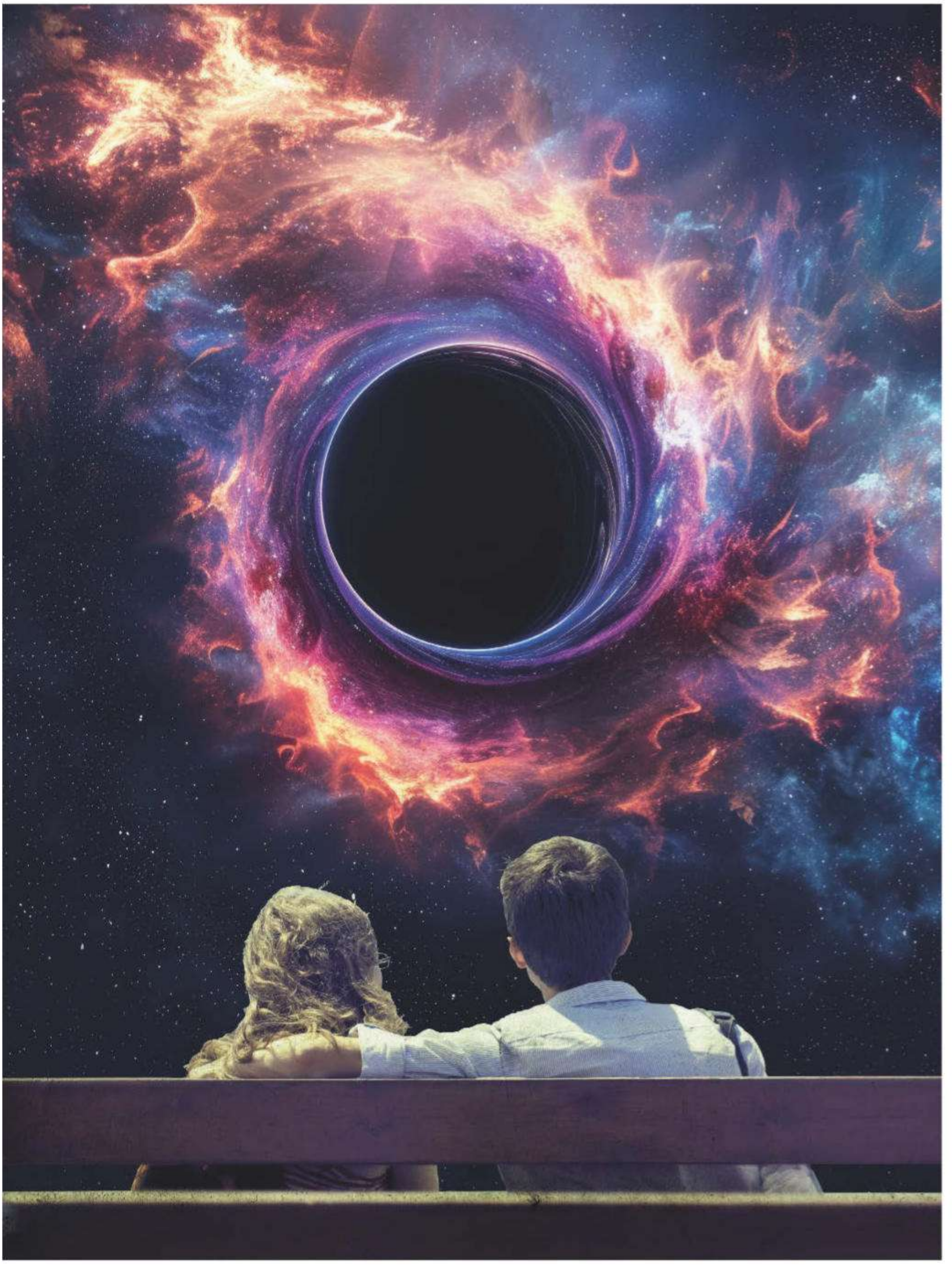
In 1969, Penrose proposed that singularities are always concealed behind an event horizon, the outer edge of a black hole where gravity becomes so strong that nothing, not even light, can escape. This is known as the "weak cosmic censorship hypothesis" because it suggests that nature forbids visible or "naked" singularities. Physicists have good reason to think it must be true – not least that the existence of naked singularities would undermine the notion of a universe in which the laws of physics can predict what happens. "As long as you're outside of the black hole, determinism is fine," says Alex Lupsasca, a black hole expert at Vanderbilt University in Nashville, Tennessee. "Whatever bad stuff is happening, is happening inside the horizon."

Naked singularities were thus "brushed under the carpet", says Pankaj Joshi, a cosmologist at Ahmedabad University in India. Never properly dealt with, the concept lives on as a nagging reminder that an unproven hypothesis is the only thing preventing general relativity from losing its predictive power.

To make matters worse, in recent years theorists have demonstrated that naked singularities can indeed pop up as consequences of general relativity and related theories of gravity. For example, some researchers predict the existence of unstable "black strings" – similar in nature to black holes – that can stretch and pinch off, leaving behind a naked singularity. Others suggest that naked singularities could also appear when black holes collide or when they evaporate completely by slowly emitting radiation. "The repertoire just keeps on getting larger and larger," says Engelhardt.

Some of these naked singularities would only occur in hypothetical universes with more than three spatial dimensions, or in universes with a different kind of space-time curvature to ours. But these results still have implications for our cosmos, says Verheijden, and so they arguably signal the end of cosmic censorship as we know it. "It's manifestly untrue," she says. "Within classical general relativity, it can definitely be violated."

And yet when we look at the night sky, we don't see any naked singularities. "That black holes exist and [naked] singularities don't, as far as we know, requires some kind of explanation," ›



ADOBE STOCK/ERIKA EROS/ALAMY/COLLARGE RYAN WILLS

says Engelhardt. "What is happening?"

To find out, in 2023, Engelhardt, Verheijden and Yang – along with MIT collaborators Åsmund Folkestad and Adam Levine – set about tackling the cosmic censorship hypothesis from an entirely new perspective. The results of their work, published in February, take the first strides towards a quantum version of cosmic censorship, says Gary Horowitz at the University of California, Santa Barbara. "It's a significant advance," he says.

Holographic universe

Instead of searching for naked singularities in classical space-time theory, Engelhardt and her team investigated the nature of singularities and event horizons within the hypothetical framework of quantum gravity, which aims to unite general relativity and quantum mechanics – the two pillars of modern physics. "We set out to find a condition that would guarantee the formation of [event] horizons," says Engelhardt.

Specifically, they used a popular quantum gravity approach called holography. The idea is that higher-dimensional space-time emerges from a lower-dimensional realm, described by quantum theory, in a way roughly akin to how a hologram is projected from a flat surface. You can translate between these two equivalent descriptions of reality using what you can imagine as a classical-quantum dictionary, known as the "AdS/CFT correspondence", in which AdS is the "bulk" space-time and CFT is the quantum surface, or "boundary".

Translating back and forth between the languages that describe the two realms, the researchers were looking to see if singularities in the bulk space-time have a signature in the boundary CFT, says Yang. They began by considering how black holes might appear in the boundary CFT.

It is conventional wisdom, at least among quantum gravity theorists, that black holes as they appear in the boundary CFT are "maximally chaotic", says Engelhardt. This means the system is sensitive to its initial starting conditions, and small changes in these can lead to vastly different outcomes. Starting with this assumption, they found that a closely related concept called "psuedo-randomness" in the CFT correlates with the existence of an event horizon in bulk space-time. "You can use that as a diagnostic for the formation of a black hole," says Lupsasca.

They called this new connection between

How to turn a quantum computer into a black hole

On the face of it, quantum computers, which leverage quantum physics to process information, have little to do with black holes. But in recent years, physicists have found hints of a deep connection between algorithms designed to make quantum computers more robust, known as error-correcting codes, and the fundamental structure of the universe.

It has to do with an approach to understanding the quantum origins of gravity known as holography, in which space-time is thought of as emerging from a flat surface, governed by quantum mechanics, as if it were a hologram. When researchers looked more closely at this model, their calculations suggested that this emergence seems to work much like a quantum error-correcting code.

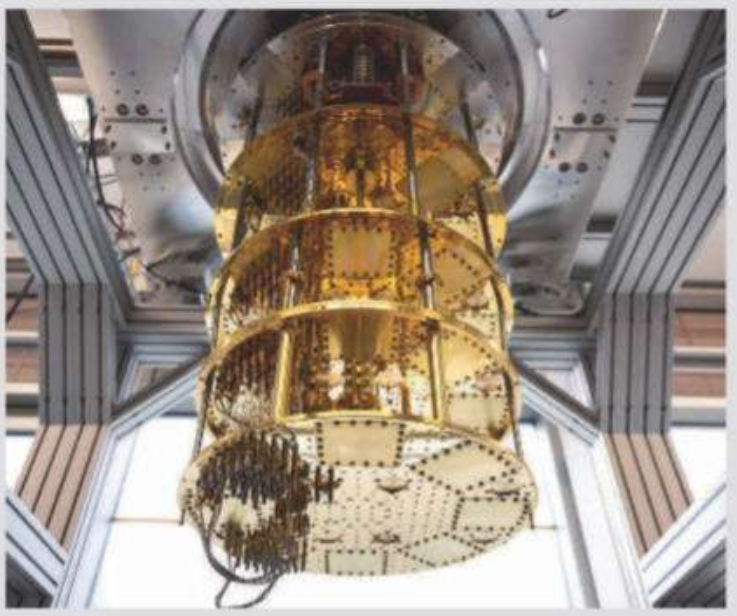
Which raises a bonkers question: if you program the quantum description of a black hole into a quantum computer, would the equivalent space-time actually emerge in its vicinity – that is, would you create a real black hole in the process? "We haven't completely bitten the bullet on these implications," says Alex Lupsasca, a black hole expert at Vanderbilt University in Nashville, Tennessee. "Maybe you have to take that seriously."

Earlier this year, Netta Engelhardt and her collaborators at the Massachusetts Institute of Technology showed how a feature of quantum algorithms called pseudo-randomness, if there is enough of it, will always lead to the formation of a black hole event horizon (see main story). We don't yet have big enough quantum computers to program them with sufficient pseudo-randomness to create a black hole. But there is nothing to stop this being done in principle, says Engelhardt.

The idea that a quantum computer can create a black hole makes more sense when you consider that programming pseudo-randomness into a computer is akin to doing a very complex calculation, which requires a lot of information. "It's a lot of qubits. It's a lot of mass in a small amount of space," says Lisa Yang, one of Engelhardt's collaborators at MIT. "And so, by definition, it has to collapse into a black hole."

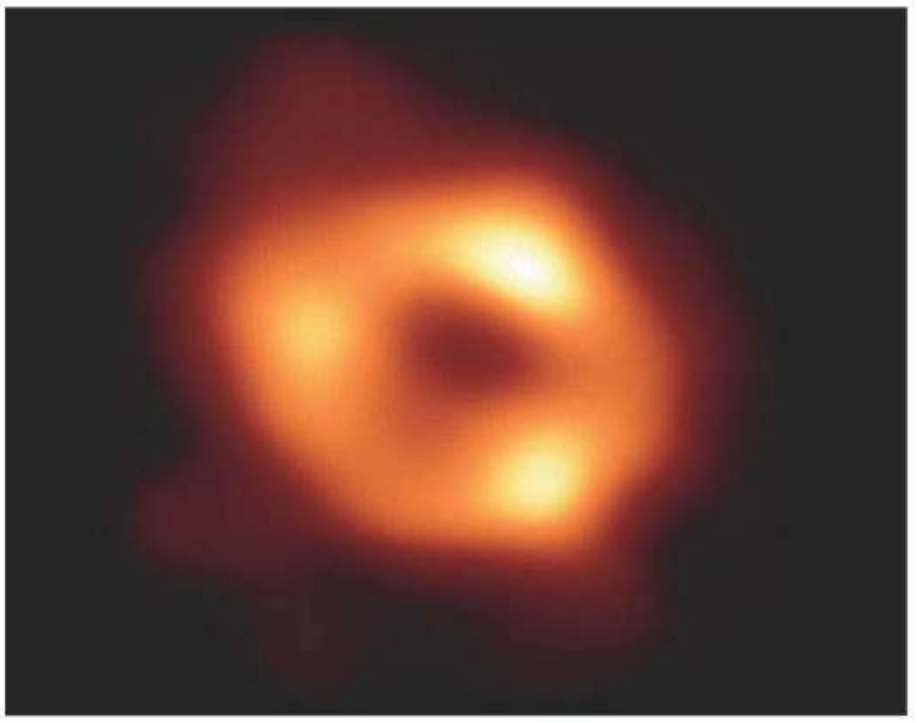
"Does that mean that you've created a black hole by doing this very complicated calculation? I think the answer is yes," says Lupsasca, who describes black holes as the "densest hard drives in the universe".

Of course, the moment a quantum computer collapses into a black hole, you can no longer access that computer. "Unless you're within the quantum computer," says Evita Verheijden at Harvard University's Black Hole Initiative. "But then you'd also be inside the black hole."



SVEN HOPPE/DPA/ALAMY

The cryostat of a quantum computer, which protects fragile quantum states



EHT COLLABORATION

The first image of Sagittarius A*, the supermassive black hole at the centre of the Milky Way

pseudo-randomness and event horizons "cryptographic censorship" because it makes use of a growing toolkit from the fields of quantum information and cryptography to solve problems in fundamental physics. Among the strange consequences of these connections is the possibility that if you program a quantum computer with enough randomness then it may turn into a black hole itself (see "How to turn a quantum computer into a black hole", left).

Using cryptographic censorship, the group then formulated a quantum version of cosmic censorship, which would go some way to explaining why we don't see naked singularities. The researchers posit that the signature of space-time singularities in the CFT is this randomness. This means that any incoming matter or fields that hit a singularity would be reflected such that the singularity appears random – effectively scrambling its appearance. "We conjecture what we call Quantum Cosmic Censorship: that in quantum gravity, classical naked singularities should not exist," says Verheijden.

To be clear, cryptographic censorship does permit the existence of very small naked singularities, in cases where there is insufficient randomness in the CFT to generate an event horizon, such as those left behind when black holes evaporate. They would just be too small to trouble determinism.

In any case, the work turns how we think about large naked singularities on its head, says Engelhardt. From the perspective of general relativity, naked singularities would be points where space-time and predictability break down. But in quantum gravity, large naked singularities would be in a "highly predictable space-time", says Verheijden.

That is because the event horizon is a result of randomness. So, hypothetically, if you were to remove the event horizon – revealing the naked singularity – it would take the randomness with it. In other words, large naked singularities, were they to exist, wouldn't be as riddled with randomness and unpredictably as we had assumed. "It's a genuinely new perspective on this thing that's unpredictable," says Engelhardt.

Quantum censorship

For all that, the quantum version of cosmic censorship isn't a watertight proof that naked singularities aren't lurking in the cosmos. For one, the curvature of space-time described by AdS/CFT isn't the same as that in our own universe. Quantum gravity theorists choose this as their sandbox to play in because it allows them to do otherwise intractable physics. "But it may or may not be related to how quantum gravity exactly works in our universe," says Lupsasca. "That's an open question." When thinking about black holes and infinities, the details of space-time structure really matter, he says.

"They showed something that has the flavour of cosmic censorship," says Daniel Harlow, also at MIT, who wasn't involved with the work. "It's more of a consequence of cosmic censorship, and if you can prove one of the consequences, then you can view it as evidence that [cosmic censorship] is true also," he says.

Indeed, Engelhardt and her collaborators are more interested in taking the "spirit" of cosmic censorship and seeing what it would mean for quantum gravity itself. For one, the AdS/CFT correspondence assumes that black holes are the most common state in that universe. This allows theorists to understand black holes within quantum gravity as thermodynamic systems, whereby you can calculate their average properties, similar to how you measure the temperature or pressure of a box of gas molecules without knowing about the movements of individual particles.

Cryptographic censorship implies that, to all intents and purposes, a naked singularity is always cloaked by an event horizon, ensuring that black holes are far more common states than naked singularities. "If it weren't true, our whole [AdS/CFT] house of cards would come crashing down," says Harlow.

By digging into the foundations of AdS/CFT, the group also hopes to better grasp the convoluted way in which the holographic dictionary translates the quantum world into gravity. That is difficult because, instead of a one-to-one translation, each patch of the bulk universe seems to be encoded on the holographic plate, or CFT, more than once, in different places. In particular, figuring out which parts of the CFT describe the singularity and which parts describe the event horizon has frustrated progress. "A lot of AdS/CFT research has been hampered by the fact that things become very mysterious behind the event horizon, and our inability to separate the effects of the horizon from the effects of the singularity," says Engelhardt.

For now, cosmic censorship remains unproven. But proving it was never really the point here. The real interest lies in what we can learn about the nature of black holes, and quantum gravity, by thinking deeply about this conjecture. And, even as it looks increasingly solid, some cosmologists, Lupsasca and Horowitz among them, are still hoping cosmic censorship isn't true. "We would be delighted to see a naked singularity," says Horowitz, "as we would actually have a way of getting observational evidence of quantum gravity." ▮

Thomas Lewton is a features editor at *New Scientist*

Ozempic on the brain

Weight-loss drugs have surprising benefits away from the gut, opening up new ways to treat depression, dementia and addiction, discovers **Simar Bajaj**

KATHY SCHWARTZ was 10 years free from alcohol, cigarettes and opiates but every day it was painful to control her cravings. "They were always in the background," she says. In June last year, however, this noise fell silent.

Prescribed the weight-loss drug semaglutide, she not only lost nearly 30 kilograms over 10 months, but also her desire to reach for a drink or take some pills. "I do not crave, which I didn't think would be a side effect," says Schwartz. Remarkably, the depression and anxiety that would previously come over her in waves also calmed down.

Schwartz isn't alone in this experience. New research is revealing the surprising brain and mental health benefits of semaglutide drugs such as Ozempic and Wegovy, and other related diabetes and weight-loss drugs that mimic a gut hormone released after eating.

It is early days, but there are hints that these drugs could be repurposed to treat depression, anxiety, addiction and even certain eating disorders – as well as neurological conditions such as Parkinson's disease and Alzheimer's. What's more, it seems that these effects aren't just mediated via weight loss, but through direct action on the brain.

The story of drugs like Ozempic starts back in the 1970s and 1980s when researchers discovered that a gut hormone called glucagon-like peptide-1 (GLP-1) could stimulate insulin production when injected into rodents in the lab. More surprisingly, these animals started eating less and losing weight. We now know that the hormone leads to an increased feeling of fullness.

Today, drugs that mimic GLP-1, such as semaglutide (sold as Ozempic and Wegovy), liraglutide (sold as Saxenda and Victoza) and tirzepatide (which also contains another satiety hormone mimic, and is sold as Mounjaro and Zepbound), have revolutionised the treatment of diabetes and obesity. Already, 6 million people in the US have been prescribed semaglutide, with the number of Americans taking GLP-1 drugs predicted to grow to 30 million by the end of the decade. Although a pill version called Rybelsus is available, these drugs are generally taken as weekly injections at home, typically helping people lose around 15 to 21 per cent of body weight. These drugs can also protect against cardiovascular problems such as heart attacks. But their widespread use has revealed all kinds of other, unexpected knock-on benefits.

In February, an analysis of more than 4 million people by medical records company Epic found that most GLP-1 medications resulted in a lower likelihood of depression and anxiety compared with controls. For instance, people without diabetes taking semaglutide were 37 per cent less likely to be diagnosed with depression, and 31 per cent less likely to be diagnosed with anxiety. Similarly, a 2023 meta-analysis found that GLP-1 drugs reduced depression in adults with diabetes compared with those on non GLP-1 treatments.

ADDICTIVE STOCK CREATIVES/ALAMY; ADOBE STOCK

Improved blood sugar control or weight loss might explain these mental health benefits, not least because there is a well-established link between obesity and depression. There is also a boost in confidence that may arise from addressing these conditions. "When patients are responding, they feel more empowered," says Sriram Machineni at Albert Einstein College of Medicine in New York. "It's not simply the mood improvement, but a feeling that they have it under control – they feel good about themselves."

However, some researchers such as Rodrigo Mansur at the University of Toronto, Canada, think that additional mechanisms are at play. After all, GLP-1s aren't only produced in the gut – they are also made in the brain, specifically the brainstem region. And, in turn, GLP-1 receptors are peppered throughout the brain, including in areas important for cognitive functions and emotional control, such as the prefrontal cortex, hippocampus and amygdala, so stimulating these receptors could be beneficial.

To test for broader effects, Mansur and his colleagues ran a small study in 2017, giving liraglutide to 19 people with major depressive disorder or bipolar disorder. Within a month, they reported better mood, attention span and cognitive function. "On average, depressive

> "The widespread use of these drugs has revealed unexpected knock-on benefits"

symptoms improved by 30 per cent in the whole sample," says Mansur. These effects were observed even in individuals who didn't lose a significant amount of weight, indicating that they weren't simply due to feeling better through weight loss.

When the researchers carried out MRI scans of the participants' brains, they found that areas involved in planning, organisation and emotional processing significantly increased in volume within a month. "We were surprised by the magnitude," says Mansur, who is now conducting a randomised controlled trial to investigate the ability of GLP-1 drugs to directly treat mood disorders.

He suspects these brain effects are rooted ›

in GLP-1's multifaceted ability to protect the brain. For starters, this hormone has been shown to increase the brain's blood flow and to slow down the death of nerve cells. It can also promote the flow of glucose to the brain, an incredibly sugar-hungry organ. Some studies in humans show that GLP-1 modulates the transport of glucose across the blood-brain barrier and the rate that the brain consumes glucose, says Mansur, increasing access to this vital energy source and hence, presumably, boosting the brain's ability to operate.

But insufficient glucose is only one of many threats to the brain. Others include oxidative stress, where unstable molecules called free radicals damage neurons, and long-term inflammation, where an overzealous immune system attacks healthy nerve cells. By binding to receptors in the brain, GLP-1 seems to reduce production of free radicals and dampen inflammation, independent of weight loss.

It is this anti-inflammatory effect that underlies GLP-1 drugs' cardiovascular benefits, reducing the risk of heart attacks, as well as their promise for treating neurodegenerative diseases such as Parkinson's and Alzheimer's disease, which are both characterised by neuroinflammation. Clinical trials so far have had mixed results, but the latest findings for Parkinson's, published in April, found that disease progression was reduced in participants treated with an older GLP-1 drug called lixisenatide, compared with controls. In tests of motor scores after 12 months, those receiving the drug had stayed roughly the same, whereas the control group had declined.

Similarly, last year a UK trial found that people with Alzheimer's who were treated with liraglutide had reduced shrinking in certain parts of their brains and less cognitive decline, compared with controls. A clearer picture of these drugs' impact should emerge late next year, when pharmaceutical company Novo Nordisk completes two trials testing semaglutide for Alzheimer's disease.

Brain protection

Some researchers suspect these drugs will work against other brain conditions, such as epilepsy and stroke. "It appears that the mechanisms that are protective in Alzheimer's disease and Parkinson's disease also show effects in other neurodegenerative disorders," says Christian Hölscher at the Henan Academy of Innovations in Medical Science in China.

"Satiety hormone receptors are found in the brain, including in areas important for emotional control"

"Since the GLP-1 action in the brain is quite broad and does not focus on a specific biomarker of a specific disease, it is easy to see that the changes induced by GLP-1 type drugs are helpful in other diseases as well."

In recent years, researchers have been taking advantage of this breadth to explore whether GLP-1s could treat addiction. For instance, in February, Patricia Sue Grigson at Penn State Neuroscience Institute presented the first clinical trial results using anti-obesity drugs to treat opioid addiction. Among 20 patients in residential treatment, those on liraglutide had a 40 per cent reduction in opioid cravings over three weeks compared with those receiving a placebo. Grigson and her colleagues are now conducting a larger trial to investigate further.

While the exact mechanism is unclear, GLP-1s seem to target addiction similarly to how they target the hunger drive, influencing two key brain regions that are involved with reward processing and cravings: the nucleus accumbens and the locus coeruleus. The idea, according to animal studies and Grigson's unpublished data, is that GLP-1s reduce activity in both regions, simultaneously reducing the pleasurable aspects of taking opiates and the negative aspects of going through withdrawal.

"The same central nervous system effects that increase your satiety and reduce your cravings are also having other favourable effects," says Chiadi Ndumele at the Johns Hopkins School of Medicine in Maryland. "We're in a new era in terms of these agents that have so many benefits."

MARIA KORNEEVA/GETTY IMAGES

Indeed, beyond opiates, GLP-1s also seem useful for treating addictions to nicotine, cocaine and other drugs. The strongest evidence yet for this came last month in a study of the medical records of over 80,000 people with obesity. This found that semaglutide was associated with around a 50 per cent lower incidence of alcohol use disorder over a 12-month follow-up period, compared with controls who were taking non GLP-1 obesity medications.

Compulsive behaviours are also associated

Drugs such as Ozempic that mimic a satiety hormone are typically administered via a weekly pen injection

FDCM/ALAMY

Symptoms of anxiety and depression can be reduced in people taking certain weight-loss drugs

with certain eating disorders, so last year, Jesse Richards at the University of Oklahoma and his colleagues explored whether semaglutide could help people with binge eating disorder, the most common type. Their study of 98 people's medical records found that semaglutide was more effective at treating binge eating disorder than the only medication approved by the US Food and Drug Administration (FDA) for this condition. Other evidence suggests that GLP-1s might also help treat bulimia nervosa, another common eating disorder characterised by episodes of overeating then purging.

If ongoing trials confirm these findings, Richards believes GLP-1s could revolutionise mental healthcare – as part of a holistic treatment regimen involving dieticians, clinical psychologists and others. "If we do find there is a reliable, say, binge eating response or alcohol use response, that's going to make GLP-1s the most common medication with this effect by orders of magnitude," says Richards.

Beyond all of this, there is a very practical way that GLP-1 drugs can improve mental health: by tackling a major side effect of many psychiatric drugs, weight gain. Antidepressants can cause people to gain 10 to 20 kilograms and antipsychotics 20 to 45 kg, says Machineni, often forcing individuals to choose between their mental health or weight.

Some people will "avoid coming to the psychiatrist, they avoid medication, they avoid things that would make their mental health better because they don't want to end up with obesity", says Tiffani Bell Washington, a Boston-based psychiatrist and obesity medicine physician. Indeed, a number of US psychiatrists consulted for this article reported that, with GLP-1s increasingly available, people have become more willing to try and ultimately stay on psychiatric medication – a critical issue given high non-adherence rates.

Yet many questions remain. The key clinical trials testing semaglutide and tirzepatide for weight loss mostly excluded people with depression, anxiety and other mental health conditions, says Machineni. That has left a major gap in the research, making it unclear what mental health side effects these higher-risk individuals might experience.

Adverse effects?

This situation came to a head last year following reports of people on GLP-1s experiencing suicidal thoughts. In July 2023, the European Medicines Agency started an investigation, but concluded in April that there was no link between these medicines and suicidal ideation. A similar investigation by the FDA is ongoing, but a preliminary evaluation in January found no causal link. Likewise, a recent observational study of nearly 2 million people found that GLP-1s were actually associated with a lower risk of suicidal ideation than other obesity and diabetes treatments.

Some experts are also concerned that people with anorexia may use GLP-1s and exacerbate their condition, or that otherwise healthy people might develop this eating disorder, characterised by extreme caloric restriction and an intense fear of gaining weight. We also don't yet know if people who aren't overweight can take GLP-1s safely for mental health reasons alone. "These medications across the board reduce appetite," says Machineni, potentially leading patients without obesity to become malnourished or even critically underweight. And if people stop taking GLP-1 medications, whether due to side effects, shortages or high costs, they might risk experiencing worse symptoms than before.

Another, potentially stickier issue is GLP-1s' cultural meaning, with some body positivity activists arguing that such drugs can damage mental health (these activists often prefer the term "fat" over "obese", which they argue is a term that pathologises larger bodies). "This whole frenzy around Ozempic, Wegovy, has got a lot of people confused that this is a good thing for fat people," says Vinny Welsby, author of *Fierce Fatty* and a consultant on anti-fat bias and diet culture. "If they're gonna make you thin, they're gonna make you happy, they're gonna end your depression – why wouldn't I take it?" What's missing in these rosy depictions is that these drugs may only be a band-aid, masking much deeper problems of weight-based discrimination and a socially disconnected society, says Welsby.

Kate Manne, a philosopher at Cornell University in New York, echoes these concerns. "A lot of fat people report having intentional weight loss pushed on them by medical professionals," she says, even if they feel comfortable with their bodies. She worries that GLP-1 drugs will only exacerbate this situation, especially given their constant promotion by influencers, celebrities and the media. "People who are bigger increasingly feel unwelcome in spaces where the question is, 'Why aren't you on Ozempic?' " says Manne. "That can have real effects on their mental health and sense of well-being."

Notwithstanding these issues, using GLP-1 drugs as everyday mental health treatments will require further research into their exact mechanisms of action, the feasibility of using low doses and their tolerability in people who don't have excess weight or obesity, says Ndumele. Perhaps one day there will be a new formulation that doesn't result in so much weight loss, but preserves the independent benefits to mental health and more.

But Kathy Schwartz has already made up her mind on semaglutide. "Just the way it's helped my mental health and decision-making, I plan on taking it forever." ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org); US 988 Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for other countries

Simar Bajaj is a freelance writer and a research fellow at Massachusetts General Hospital

The age of de-extinction?

The same tools being used to try to resurrect the dodo could help many other vulnerable species that have yet to die out, finds **James Dinneen**

JPGFACTORY/GETTY IMAGES

VIKASH TATAYAH had never heard of Colossal Biosciences until the Texas-based company announced plans last year to bring back the dodo. Widely known for wanting to "de-extinct" the woolly mammoth, it said it was making strides in the genetic engineering of dodo-like birds, which would then be brought to Mauritius, one of the Indian Ocean's Mascarene islands and the dodo's sole habitat before extinction.

As conservation director at the Mauritian Wildlife Foundation, Tatayah had worked for decades to conserve the nation's surviving endemic species, from the Mauritius fruit bat to the pink pigeon, a dodo relative. So he was surprised that his organisation wasn't in the loop – and somewhat sceptical of the motives behind the multi-million-dollar project. "I was the first to say, 'Hold on. There are a lot of other species of plants and animals on Mauritius that are threatened. That money could be better spent.'"

Whether genetic engineering should be used for conservation remains contentious, and many are especially wary of de-extinction. But a year later, Tatayah sees the potential return of the dodo as a way to simultaneously rescue endangered species – in particular the pink pigeon. "We are very keen for the dodo to be brought back," he says.

Often overlooked is that the biotech breakthroughs Colossal and others are working on could have important collateral benefits. They could clear a path to using genetic tools to quickly help a whole range of animals resist the pressures they face from a changing environment. "The pace of change is faster than evolution by natural selection can keep up with," says Beth Shapiro, the chief science officer at Colossal.

The dodo's disappearance from Mauritius ranks among the most notorious of human-caused extinctions. Less than a century after the first Dutch sailors arrived on the uninhabited island in 1598, the big-beaked, ungainly birds that the Europeans described as "twise as bigge as swans" were all gone. Only a few specimens remain preserved in museums. Even drawings of the birds are rare.

But the dodo was far from the only species on Mauritius decimated by the appearance of sailors and their non-human stowaways. "There were so many species that went extinct before anyone had heard of them," says Camilla Ryan at the Earlham Institute in the UK, whose PhD focused on the plight of the pink pigeon on the island.

For centuries after the dodo's demise, the pink pigeon – along with the rest of Mauritius's native species – struggled to survive the new arrivals. Along with the sailors came cats and rats, and later macaques, all of which fed on bird eggs. Mongooses were introduced to deal with the rats – but they ate the eggs too. And a disease carried by the newly introduced species killed young birds. Invasive plants and sugar cane plantations fragmented the pink pigeon's coastal forest habitat. "There's nowhere to escape," says Ryan.

By 1990, there were just 10 pink pigeons identified living in the wild. "It's the last living pigeon of the Mascarenes," says Tatayah, who began captive breeding and habitat restoration efforts to boost the population around this time. Today, Tatayah says there are about 600 of the rose-tinted birds there, and the population appears to be stable. "We've turned back the tide," he says.

But a risk of extinction remains. Passing through a low-population bottleneck has resulted in a deficit of genetic diversity among the remaining birds – a situation common to many endangered species. In 2022, Ryan and her colleagues measured the diversity among more than 100 of them. They then modelled how interbreeding and the loss of diversity from random genetic drift would, over many generations, reduce the fitness of offspring and so affect the long-term survival of the species. They found that if no outside diversity was introduced, the pigeons were likely to go extinct by the end of the century. Considering the long-term picture is vital. "You cannot think in 10 or 20 years' time," says Ryan. "You've got to think in 200 years' time."

Pink pigeon rescue

One way to introduce diversity is to interbreed wild pink pigeons with their captive peers. As part of earlier conservation efforts in the 1970s and 80s spearheaded by the British naturalist Gerald Durrell and a far-sighted conservationist named Carl Jones, 17 of the birds had been brought into captivity at a zoo on the island of Jersey in the English Channel. Today, offspring of this population are held in several zoos in the UK and the US, and a handful have been reintroduced to Mauritius.

"There is a lot of diversity still present in the zoos. That is the first port of call," says Cock van Oosterhout at the University of East Anglia in the UK, an expert on pink pigeon genetics. But, he says, this still may not be enough to avoid extinction in the long run. The birds were captured from an already declining ›

MARK CARWARDINE/NATUREPL.COM

STEEVE-X-ART/ALAMY

Similar biotechnology involved in bringing back the dodo (below) could also help to save the pink pigeon (left), a species also endemic to the Indian Ocean nation of Mauritius (bottom)

population, and many may be related to birds on the island today.

There is, however, another source of pink pigeon diversity: DNA preserved in museum specimens. But resurrecting that lost genetic variety would require much the same techniques as resurrecting an extinct species. "Maybe we need to reach into the toolbox of de-extinction," says Shapiro.

Since launching in 2021, Colossal has raised hundreds of millions of dollars of investment and captured headlines for its plans to bring back the woolly mammoth, the thylacine (also called the Tasmanian tiger) and now the dodo.

But, strictly speaking, it isn't planning to bring back animals identical to those that went extinct, which company leaders acknowledge is essentially impossible. Even high-quality reconstructions of extinct genomes using preserved DNA will contain important gaps. This means that any organisms developed using the this DNA would have significant differences from the extinct species.

Instead, the company aims to engineer proxies of extinct species that can serve similar ecological functions. Instead of creating woolly mammoths, Colossal aims to use the mammoth genome as a guide to edit the genomes of contemporary elephants in order to create furry elephants that can survive in frigid conditions. In the case of the dodo, it plans to edit the genome of a related pigeon species called the Nicobar pigeon to create a big-beaked, flightless bird. "The dodo is just a fat pigeon," says Shapiro.

The spotlight created by these and other de-extinction projects has also spurred debate about the ethics of trying to bring back extinct species. For instance, a De-extinction Task Force at the International Union for Conservation of Nature (IUCN) identified a number of possible drawbacks, including threats to the welfare of cloned animals, unknown ecological impacts of introducing proxy species and the prospect of "re-extinction", in which a resurrected species gets wiped out again.

Another common criticism from conservationists is that a focus on futuristic de-extinction efforts undermines work to prevent the disappearance of the estimated 1 million still-living species that are on the brink. "I think things like the dodo and the woolly mammoth are a distraction," says Phil Seddon, a zoologist at the University of Otago in New Zealand, who chaired the IUCN task force. "The best application of de-extinction technologies is to avoid extinction in the first place," he says.

SHUTTERSTOCK/MYROSLAVA BOZHKO

Ben Lamm, Colossal's CEO, counters that the company has been working on conservation projects beyond de-extinction from the beginning. "We just weren't talking about it," he tells me over coffee at a hotel in Manhattan, where he has come for a screening of a documentary about the American bison, another genetically restricted species he says the company's technology could aid. "Most people just want to talk about de-extinction."

Colossal's publicity material now makes this wider mission clear. Each extinct species it has targeted is paired with a living "sister species", which Lamm says the company will use its considerable financial and technological resources to help. Alongside the woolly mammoth, for instance, it is studying gene editing methods to reduce the Asian elephant's susceptibility to a deadly herpesvirus. The company's researchers recently reported they had figured out how to make regular elephant cells into stem cells that could be used for this and other purposes in a breeding programme. Alongside efforts to bring back the thylacine in Tasmania, they are supporting conservation of the Tasmanian devil. And a related project will edit northern quoll cells in an effort to make the tiny Australian marsupial resistant to the toxins of the invasive cane toad.

The pink pigeon is another example. After Tatayah heard about the dodo project, he got in touch with Colossal to discuss the organisation's conservation work on Mauritius. He says the company was receptive. And, in November last year, Colossal and the Mauritian Wildlife Foundation announced they were working together to restore habitat on Mauritius in preparation for the arrival of dodo-like birds. Moreover, the gene editing tools being developed for the dodo will be used to restore lost genetic diversity to the pink pigeon. "Conventional conservation works. It just doesn't work at the speed and scale we need it to," says Lamm.

In many ways, the technical challenges involved in restoring lost diversity to the pink pigeon are the same as those involved in bringing back the dodo, says Shapiro. Both require sequencing DNA from degraded samples, determining where those fragments fit in the genome, then editing

Biotech to the rescue?

Researchers are already using biotechnology to support the "genetic rescue" of several species threatened with extinction, due in part to their low genetic diversity. Here are some of the latest examples:

PRZEWALSKI'S HORSE

Two stallions of this endangered central Asian horse were recently produced by cloning the cells of a specimen frozen in the 1980s. The researchers say this is the first example of two healthy clones born from an endangered species.

AMERICAN CHESTNUT

Billions of American chestnut trees were wiped out in the 20th century by an invasive fungal disease. Researcher have now developed a gene-edited version of the tree that is resistant to this pathogen. However, it has struggled to gain government approval to be planted beyond the lab.

NORTHERN WHITE RHINO

Just two northern white rhinos are still living – and both are female. Researchers have developed a method to reprogram rhino skin cells so they can develop into sperm and egg cells. If those cells produced viable offspring, they may create enough genetic diversity to ensure the rhino's long-term survival.

BLACK-FOOTED FERRET

Researchers are working on ways to edit the black-footed ferret's genome so it is resistant to sylvatic plague. Susceptibility to the disease prevents captive ferrets from being released back to the wild.

L–R: SHUTTERSTOCK/YERBOLAT SHADRAKHOV; PANTHER MEDIA GMBH/ALAMY; OL PEJETA/DPA/TNS/ALAMY; SHUTTERSTOCK/KERRY HARGROVE

DNA in living cells to match key sequences.

However, long before approaching the egg-laying stage, the researchers face a hurdle unique to avian species. For other animals, edits can be made to adult body cells. These can then be cloned and grown into a full organism by replacing the nucleus of a fertilised embryo with the nucleus of one of the edited cells. But this form of cloning isn't possible for birds because the microscopic nucleus is hidden within the vast yolk of the egg. "It is a universal problem for advancing biotech in birds," says Ben Novak at Revive and Restore, an organisation developing genetic engineering tools for conservation and de-extinction.

A workaround is to make edits to the precursors of reproductive cells called primordial germ cells (PGCs). These can be collected from an embryo and then grown in a lab, where multiple edits are made to their DNA. After PGCs differentiate into full sperm or egg cells within a surrogate parent, they can be used to create an embryo that will grow into a bird with all the edited DNA. But so far, growing PGCs has proven challenging for most bird species. "Birds are among the most endangered species in the world, and we don't have any way of using genetic tools to edit their genome," says Shapiro.

Colossal's approach to dodo de-extinction requires growing PGCs of the Nicobar pigeon in the lab. And it seems to be making progress. In November, the company announced it had successfully cultured Nicobar pigeon PGCs and found they could survive within a chicken, which could be used a surrogate parent for future clones. It is using a similar approach to culture the PGCs of pink pigeons. And in principle, these methods could be developed to genetically rescue any other bird, says Shapiro.

Similar approaches have already been used for conservation efforts of some other animals with less challenging embryos than birds (see "Biotech to the rescue?", above). In 2020, Novak and his colleagues successfully cloned the endangered black-footed ferret, one of North America's most threatened mammals, from a cell that had been frozen in the 1980s taken from a ferret named Willa. Two other Willa clones were born just last year. Those clones could add Willa's genetic diversity to the population of black-footed ferrets, but, as with the pink pigeon, museum specimens might contain even more genetic variety. Given the pace of change and the scale of the threat to biodiversity, there isn't time to wait, says Novak. "We have to stop being afraid of using nature as an experiment."

> "Conventional conservation works. It just doesn't work at the speed and scale we need it to"

This approach could be helpful for other species with similarly restricted genetic diversity, says van Oosterhout. However, he doesn't think this elaborate and intensive genetic rescue on its own can hold the line against the threats faced by thousands of other species. "It's a bit like Sisyphus pushing a boulder up a hill," he says. "At the same time there are hundreds of boulders running down."

Meanwhile, Tatayah, while continuing to push boulders on Mauritius, is planning in earnest for the arrival of dodo-like birds. He points to the endangered tambalacoque tree – sometimes called "the dodo tree" – which has struggled to reproduce in the centuries since the dodo vanished. The planned dodo-like birds may help to disperse the seeds of this long-lived plant by chewing and digesting its fruit, as dodos themselves may have done. However, so little is known about the dodo that it isn't clear whether it actually ate this fruit. It isn't even known where on the much-abused island of Mauritius the dodo preferred to spend its days, says Tatayah. "There's going to be a lot of discovery." ▮

James Dinneen is an environment reporter at *New Scientist*

The back pages

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***Almost* the last word**
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The science of baking

Puff piece

After a lifetime of avoidance, **Catherine de Lange** discovers that puff pastry isn't hard to make – you just need a bit of time

Catherine de Lange is the editor of *New Scientist* and an avid baker

WHEN it comes to baking, I firmly believe it pays to make things from scratch. But there are a few exceptions, one being puff pastry. I have seen enough baking shows where contestants lament the perils of making pastry on a warm day to know that puff pastry is hard, and the stuff from the packet does the job perfectly well. Life is too short for all that stress, right?

Well, I was wrong. Last week, I was in France, home of the perfect pastry, and on a rainy weekend I decided it was finally time to give it a go. I opted for a tarte tatin – that classic French upside-down tart of soft caramelised apples with a pastry base (but also popped out for emergency patisseries just in case of disaster).

The beauty of puff pastry is the glorious rise and air pockets that give it that light and flaky texture. The rise comes from layers of fat sandwiched between layers of dough. In the oven, the butter melts and releases moisture, which evaporates, causing air pockets in between the now buttery layers of pastry. You will know a good puff because it will have distinct layers – known as lamination.

Key to lamination is keeping the fat used to create the layers cold, to stop it combining with the rest of the pastry. Start by making your dough. Rub the room-temperature butter into your dry ingredients, then gradually add the water until the dough comes together. Knead briefly, then wrap in cling film and place in the fridge for an hour.

Place the larger, cold block of butter between two pieces of greaseproof paper and use a rolling pin to whack it into a 15-centimetre (6-inch) square. Put that in the fridge too – you want the dough and butter to be a similar firmness.

When both are cool, it is time for the folding. There are various options here, but I went for the letter fold. Roll your dough out into a rectangle about 46 by 15 cm (18x6 in) and place the butter in the middle. Fold the bottom of the pastry over it, then the top, as if folding a letter, to make three layers. Rotate by 90 degrees, roll out to the same dimensions and repeat. Refrigerate for 30 minutes, then repeat the rolling, folding and chilling two more times.

For the tart filling, put the butter and sugar into an oven-proof pan and let it melt over a low heat on the stove. Pack the apples tightly in the pan and leave to simmer for around 40 minutes, until the caramel is slightly golden and the liquid has evaporated. Preheat the oven to 190°C (375°F).

Now roll your pastry out to about 3 millimetres thick on a lightly floured surface and cut out a circle slightly bigger than your pan. Lay the pastry over the apples and tuck in the sides neatly. Bake for 25-30 minutes until the pastry is golden. Leave to cool slightly, then turn out onto a serving plate.

The difference in flavour was phenomenal compared with shop-bought pastry. And my emergency pastries remained in their box. ▮

DAVID SMITH/ALAMY

What you need

For the puff pastry:
450 g (3¾ cups) flour
1 tsp of salt
240 ml (1 cup) water
2 tbsp sugar
115 g (1 stick) room-temperature butter
225 g (2 sticks) cold butter

For the tart filling:
1-1.5 kg (2-3 lbs) of apples
70 g (5 tbsp) butter
185 g (1 cup) sugar

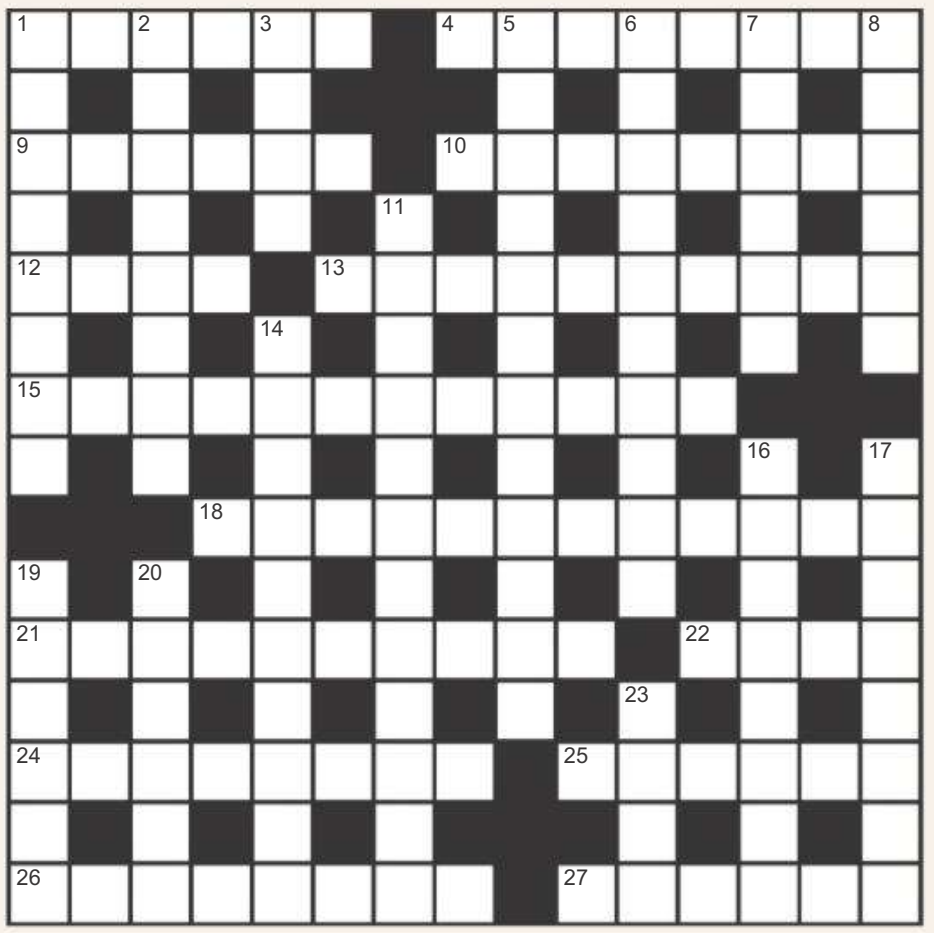
The science of baking appears monthly

Next week

Dear David

These articles are posted each week at newscientist.com/maker

Quick crossword #160 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Uncanny feeling of repetition (4,2)
4 Stress hormone (8)
9 Thick foam (6)
10 Ore treatment process (8)
12 Diminish (4)
13 Mt (10)
15 Early programming device, used in looms (8,4)
18 Orthopterans (12)
21 Eurasian songbird, *Chloris chloris* (10)
22 Level; echelon (4)
24 Nourishing substance (8)
25 Nematode that parasitises the human eye (3,3)
26 Reduced, lowered (8)
27 Marine fish in the family Labridae (6)

DOWN

1 Japanese research station in Antarctica (4,4)
2 Yellowing of the skin (8)
3 Immense (4)
5 Cell dysfunction caused by an abrupt shift in solute concentration (7,5)
6 Steering cable, on a ship (6-4)
7 Distillation (6)
8 Chickpea, alfalfa or clover, for example (6)
11 The study of nervous systems (12)
14 Isolation for medical reasons (10)
16 Blisters or fluid-filled cells (8)
17 Login detail (8)
19 ___ breathing, laboured respiration that precedes death (6)
20 Male reproductive glands (6)
23 2^2 (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #256
set by Bethan Ackerley

1 In which year did the Cassini spacecraft enter its orbit around Saturn?

2 Who is credited with taking the first measurement of the speed of light?

3 The conversion of fatty acids and glycerol into fats is known as what?

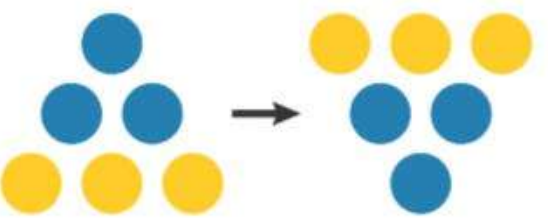
4 Atbash, Caesar and Vigenère are all early examples of what?

5 What name is given to the point beneath Earth's surface where an earthquake originates?

Answers on page 47

BrainTwister
set by James Grime
#24 Coin flips

We can flip this triangle made of coins, from one pointing upwards to one pointing downwards, by moving three of the coins (coloured dark blue), as shown in the image below.



However, it is also possible to flip this triangle upside down by moving two coins. Can you find a way?

What about a triangle with four rows? What is the fewest number of coin moves needed to flip that triangle upside down?

How about bigger triangles? Is there a general rule?

Solution next week

Tea time

Will my tea cool more quickly if it is left out at room temperature, or if my hands are cupped around the mug?

Hillary Shaw
Newport, Shropshire, UK
Logically, your hands will cool the tea faster. The tea will be at about 80°C (176°F), with the air at say 20°C (68°F). Your hands will be just below core body temperature, say at 35°C (95°F), so not that different from the air. However, water (the main component of human body tissue) is a much poorer insulator than air, so your hands will conduct heat from the cup faster than the surrounding air, as the broken cup on the floor testifies, after you involuntarily dropped it because it was scalding your hands.

Bryn Glover
Kirkby Malzeard, North Yorkshire, UK
Almost anything conducts heat better than air, so wrapping your hands around the cup will immediately extract more heat. However, hands are also good insulators, especially when wrapped in woolly sleeves, so keeping your hands in place may actually slow down the process.

"Almost anything conducts heat better than air, so wrapping your hands around your mug of tea will extract more heat"

If you wish to cool the mug more rapidly than in air, I would recommend alternately wrapping your hands around the mug, then cooling them by wafting them in the air, repeating this each time your hands reach their maximum tolerable temperature.

Don Sandom
Reading, Berkshire, UK
Yes, the tea will cool quicker if your hands are clasped around the mug which contains it.

This may seem counterintuitive, since the layer of pudgy digits could be seen as adding thermal insulation to the surface of the mug. The applied hands will, however, have a perspiration function and blood circulation, both acting to keep the core temperature of the drinker's body at around 36°C to 37°C (97-99°F). Since those are temperatures below that of drinkable tea, I would expect these mechanisms in the hands to actively transfer heat energy away from the higher-temperature tea within the mug.

Significantly, the contact between the mug and hands offers better heat transfer than will occur between your cup and free air, so that heat will be lost more rapidly from the mug when the hands are in position around it.

A way for hands to be used to keep the tea warmer would be to cup them over the top of the mug, rather than around the sides. This will reduce the airflow from the exposed top surface of the tea, which is probably the major source of energy loss, by evaporation as well as convection.

Mike Follows
Sutton Coldfield, West Midlands, UK
There are too many variables to give a definitive answer. My suspicion is that holding an insulated cup might speed up the cooling a tiny bit whereas cupping a ceramic mug might slow down the cooling. To be sure, this would require an experiment, the sort that might get nominated for an Ig Nobel prize.

SHUTTERSTOCK/MARTIN MECNAROWSKI

Birds like this blue-naped parrot evolved green plumage, so why didn't mammals get green fur?

With the lid removed from my insulated cup, a hot drink can stay warm enough to be pleasant to consume for up to an hour. Most cooling occurs via the latent heat of evaporation – in which some of the thermal energy in the drink is used to turn some of the contents into vapour – supplemented by thermal conduction to the air above the liquid. Doubtless this air could then undergo small-scale convection.

I suspect holding the cup would risk cooling the contents a tiny bit quicker as I might inadvertently agitate the liquid, increasing the surface area from which evaporation could take place. Moving the air above the liquid by talking or breathing over the surface might increase the rate of evaporation, by replacing humid air with drier air.

Tea cools quicker in a ceramic mug because there is significant heat loss through the walls. I imagine that most heat loss is via radiation from the outside surface, so a darker-coloured mug should cool quickest, as should one with a higher thermal conductivity.

There is a rapid initial drop in tea temperature when the tea is poured into the mug as some thermal energy is used to warm the mug, which stops only when the tea and mug reach thermal equilibrium. This drop is bigger for a mug with a greater heat capacity, which is a measure of the energy needed to raise its temperature.

This week's new questions

Going green **Why didn't green fur evolve among mammals, when there are birds with green plumage and reptiles with green skin?** ***Marc Russo****, Brooklyn, New York, US*

Breaking the ice **When I look for ice cubes for an evening gin and tonic, I often find they have shattered in the mould. What causes this?** ***John Neimer****, Stoborough, Dorset, UK*

Frozen in place

Why do victims of violent attacks sometimes take no immediate action, and how can we learn to react appropriately?

Anne Barnfield
London, Ontario, Canada
A violent attack is a highly stressful situation. In the past, it was thought that responses to this were the classic "fight

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Tom Gauld
for New Scientist

NOBODY ATTEMPTS TO FORMULATE A DEFINITIVE THEORY OF CONSCIOUSNESS WITHOUT BIG ANTONIO'S BLESSING.
RESEARCHERS LIVED IN FEAR OF A VISIT FROM THE NEUROSCIENCE MOB.

or flight", to fight back or flee. More recently, the concept was modified to "fight, flight or freeze", which acknowledges that, in some cases, an individual doesn't immediately react.

These actions are part of the "alarm" stage of the stress response (followed by resistance and exhaustion). In this stage high physiological arousal occurs; the sympathetic nervous system fires up the body by releasing the stress hormones cortisol and adrenalin, also known as epinephrine.

The stress response isn't all physiological, however. Cognitive appraisal and perceived control – how the person thinks about the situation and perceived threat – are important. There is thus an integration of psychological and physiological systems, with activation of different neural pathways involved.

One way to learn to react appropriately is to prepare for such experiences by training both body and mind to be ready to react (to fight or flee) rather than to freeze. Participation in traditional martial arts such as karate, judo or taekwondo can be helpful.

"Martial arts can be helpful in learning how to react appropriately, and not freeze, in the event of an attack"

Although one might think this form of training would lead to aggression, it actually has the opposite effect, due to the self-discipline it encourages. Training in self-regulation thus occurs. Visual imagery is used in learning and practice – imagining blocking attacks and countering the assailant's moves.

Research has shown that imagining actions tends to activate the same brain pathways as does performing them, and training in martial arts would have that effect.

The person who has practised making a fast response in training sessions will then be more likely to realise this in real life, for self-defence in the stressful situation of a physical attack.

Best thing since

What is the best way, and best knife to use, to minimise crumbs when slicing bread, particularly wholemeal? (continued)

Jeff Hecht
Auburndale, Massachusetts, US

When I was writing for a laser magazine many years back, I heard of the first test of laser slicing of bread. A persistent baker showed up at early laser companies in Silicon Valley and asked them to try slicing loaves of bread for him. The staff said they didn't do that, but referred him to Coherent, a rival company, and told him to insist on talking to their "expert in slicing bread", giving him the name of the Coherent president. The baker went to Coherent, where he persuaded the company to try it. Like Hubert van Hecke, who described his test in these pages, Coherent had access to a carbon dioxide laser, which it fired up and used to slice a loaf or two. The result was burnt toast, and it persuaded the baker to go away. ▮

Answers

Quick quiz #256 *Answers*

1 2004
2 Ole Rømer
3 Lipogenesis
4 Ciphers
5 The hypocentre

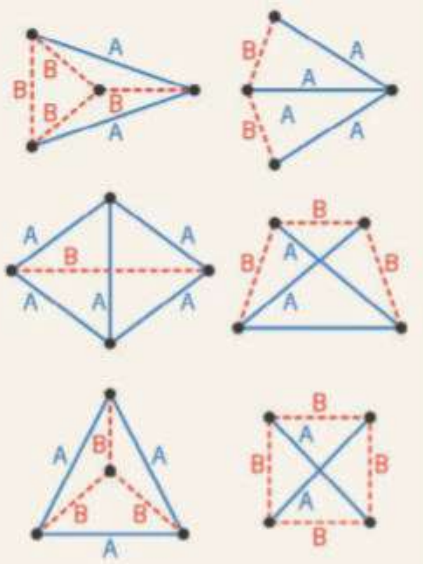
Cryptic crossword #137 *Answers*

ACROSS 1 Move, **3** Seraphim, **9** Goof off, **10** Sushi, **11** Femur, **12** Wombat, **14** Oxygen, **16** Hi-tech, **19** Tartar, **21** Hokum, **24** Therm, **25** Pacific, **26** Andirons, **27** Marl

DOWN 1 Megaflop, **2** Vroom, **4** Elf owl, **5** Assam, **6** Hostage, **7** Maim, **8** Hoarse, **13** Chemical, **15** Year-end, **17** In hock, **18** Trepan, **20** Timer, **22** Kafka, **23** Etna

#23 Four points, two distances *Solution*

There are six possible ways to arrange four points so that the distances between pairs of points all take one of two values. This is the full set of possible solutions, although some solutions may be rotations or reflections of these.



Mid-air collision

To learn whether air taxi passengers need worry about collisions with birds, a crash programme in Germany did some tests.

What with the complexity and danger of having actual air taxis have congress with actual birds, perfection was out of reach. So the experimenters made do, dropping artificial "bird projectiles" onto a metal plate rigged to measure the impact force.

Aditya Devta and Isabel Metz at the German Aerospace Center and Sophie Armanini at the Technical University of Munich describe these violent encounters in a preprint article. (Thanks to reader Mason Porter for alerting us to it.)

This work was, of necessity, a rough step towards reliably answering the big question.

It encountered difficulties, starting with "inconsistencies and lack of repeatability due to human involvement as the bird projectiles were dropped manually by hand". Future efforts, the report says, "will eliminate the human involvement [so as to] increase accuracy in force measurements and repeatability".

Twisteddoodles *for New Scientist*

I'M A FIRST YEAR PHD STUDENT
WELCOME TO MY FIRST TALK I WAS TOLD I SHOULD GIVE
THIS IS MY PROJECT
WE ARE STILL USING THE ORIGINAL PROJECT TITLE
THESE ARE MY RESULTS
WE SHOULD CHANGE THE PROJECT TITLE
ANY QUESTIONS?
PLEASE DON'T ASK DIFFICULT QUESTIONS UNLESS YOU LIKE LONG SILENCES
@twisted doodles

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Consideration of items sent in the post will be delayed

Mid-track collision

Speaking of birds-and-air-taxis-ish experiments, have you heard the one about the moose and the bullet train? Yong Peng and his colleagues at Central South University in China have begun to examine what might happen when these heavyweights meet at high speed, in the paper "Analysis of moose motion trajectory after bullet train-moose collisions".

The question involves more than the initial, simple impact. The scientists mention two not-unlikely complications: "A moose lying on a track after a crash may increase the risk of train derailment" and "a moose thrown into the air during a collision may also hit and damage the pantograph, which prevents a train from running".

The investigation so far has been done with finite-element mathematical simulations and some not-very-heavyweight experiments. The experiments used fresh beef – beef from cows, not moose – muscle tissue and a kind of stress-strain testing machine known as a "split-Hopkinson pressure bar".

The scientists report that, essentially, the impact force "depends on the contact area between the train and the moose".

As to those complications: "The moose would be pushed away by the V-shaped locomotive and would not cause a derailment, and the height of the moose thrown into the air cannot reach the height of the pantograph, which would prevent damage to the pantograph of a bullet train."

The study suggests that bigger things are approaching: "only the scenario of a train impacting a moose across a track at a speed of 110 km/h was simulated, which cannot fully reflect the risks of train-moose collisions. Thus, more speeds and postures are needed to enhance our study, which is ongoing."

Feeling saucy

Slowly, sweetly, new sauce insights pour in from readers. These pertain to the off-label usage of ketchup and other sticky foodstuffs to make electrocardiogram (ECG) electrodes work well (Feedback, 25 May).

Brian Reffin Smith adds a musical note: "You don't need human skin to test whether electrodes work better with ketchup than with official gel. I have a device which applies a low voltage to plant leaves (or anything else) and then translates the varying current into MIDI signals, sent to a computer or synthesiser to trigger sounds... Anyway, statistically insignificant but anecdotally and culinarily interesting tests reveal that a reduced salt ketchup applied between ECG electrodes and a chilli plant's leaf produced a quite high E, whilst the proper gel on a neighbouring leaf played G. I thought this might help, but now I don't think so."

Dave Hardy contributes a practicality claim: "My GP in the early 1970s said that the gel was ridiculously expensive, but strawberry jam worked just as well. I don't know if he'd experimented with different options or just used what he had to hand. (This was in the Falkland Islands.)"

Star deaths stars

It's surprising how few people are hailed as being a "celebrity pathologist", isn't it? The Associated Press brings news of the death of one of them: "Dr. Cyril Wecht, celebrity pathologist who argued more than 1 shooter killed JFK, dies at 93".

One of the first celebrity pathologists, Bernard Spilsbury (1877-1947), helped establish London's reputation as the go-to place for entertainingly clever murder mystery investigations.

The Royal College of Physicians made clear, postmortemly, that Spilsbury's career was quite theatrical: "The famous Crippen trial, on which he worked with [William] Wilcox to show that the murder was due to hyoscine hydrobromide, brought him the first blaze of publicity which he deplored in every succeeding trial at which he appeared, and this was undoubtedly why he assumed an austere and frigid manner to all but his intimate friends."

Spilsbury's manner was nothing to sniff at. One aspect of postmortem work – the dreadful stink of decaying dead bodies – deters sensitive people from entering the profession. Spilsbury wasn't a sensitive person in that respect. His peers marvelled at what an obituary politely said was a "defective sense of smell". ▮

Marc Abrahams

Can you help the gibbons survive in their natural habitats?

ENTER TODAY

Build THE Change

New Scientist and the LEGO Group's social impact program, Build the Change, have launched a competition to help gibbons survive in their fragmented forests. The challenge is to design a solution to help gibbons navigate the threats they are facing.

Finalists will get to work with LEGO® Master Builders to build their solution at New Scientist Live, and their ideas will inspire a real-life invention built by engineers at Imperial College London. The winner will be announced at the show. Finalists and highly commended entries will also win LEGO kits and tickets to New Scientist Live, 12-13 October at ExCeL London.

The competition is open to UK residents* aged 11-14 and includes two categories: i) Schools and ii) General Public. The competition closes on 30 June.

Find out more

newscientist.com/gibbons-competition

*Except residents from Northern Ireland. Please see newscientist.com/gibbons-competition for full terms and conditions

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